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Lectures on Industrial Psychology

BY

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PREFACE

TO THE SECOND EDITION

THESE lectures were designed for general audiences. They were delivered at the Sydney University, under the auspices of the Workers' Educational Association in 1916, and again in 1917 under the auspices of the University Extension Board. In the present edition, the text of the first edition has been altered in a few important particulars. The chief change has been made in the first section of the fourth lecture, which has been largely rewritten and is now a more intelligible presentation of Scientific Management than it was in the earlier edition. For the rest, a few paragraphs have been added here and there, and some inaccuracies eliminated.

B. MUSCIO.

CAMBRIDGE, *October*, 1919.

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Lecture I.

THE IMMEDIATE AIM OF INDUSTRIAL PSYCHOLOGY

§ 1

Introductory Considerations

The present lecture is largely of an introductory character. In it I propose to deal with certain questions more or less closely related to the special subject of this course, and to indicate as precisely as I can what is the immediate aim of industrial psychology.

First of all, I wish to guard against a misapprehension which may possibly arise at various points as I proceed. As it will be impossible to qualify many of my statements in such a way as to make them, scientifically, perfectly precise, I may give the impression that psychology is a completed body of exact knowledge. The fact is, however, that the science of psychology is in no sense complete, nor is it as extensive and precise as we could wish or as it certainly will be in the future. Along with a possible misapprehension on this head, there is another, which concerns the extent of the field within which industrial psychology is at present applicable. In a sense that field has no boundaries

except the boundaries of the industrial world. This statement, however, is subject to certain modifications. On the one hand, there are some psychological facts that have little relevance to industry, so far as can be seen at present: such a fact, for instance, is *coloured audition;* and, on the other hand, we are ignorant in some cases of psychological laws which, we see, are relevant to certain aspects of industry: for instance, we do not yet know, in any fulness, the rôle played by *fear* in industrial life. It must not be thought, therefore, that there are to-day no limits to the application of psychology to industry. We have, however, a considerable body of fairly precise psychological knowledge which is relevant to industry, as industry exists to-day; we possess the idea of the possibility of applying this knowledge systematically; and there are, to guide us in this enterprise, accounts of a number of attempts to apply parts of this knowledge. More than this we do not possess at present; and although the results obtained from some applications of psychology to industry are remarkable, the limitation of the sphere in which they have been obtained makes it most fitting to be somewhat modest in delineating the possibilities of industrial psychology. As my remarks may frequently give no evidence of this attitude, I wish to preface my lectures with a general statement to this effect.

I wish, next, to point out that at least *one* of the ideas that have, in recent years, prompted

different men to apply psychology to industry, is by no means new. This is the idea that, in a well-organised state, citizens might, with profit to everyone, be given the employments for which they were severally most fitted by nature. In saying that this idea is not new, it is not meant that it is merely some twenty or fifty years old. Before the Christian era we find Plato meditating upon it. Indeed, Plato *accepted* this idea, as also the fact that some persons are naturally fitted for some of the kinds of duties incidental to a well-organised state, while others are not. Plato's chief concern, however, was for the selection of guardians and rulers according to fitness, and especially the rulers. He did not think it a matter of very great importance whether the principle of selection according to natural fitness was applied to industrial workers or not. If a man were to be a ruler who had no fitness for that function, he thought the result would be disastrous, and similarly with respect to the guardians; but if a cobbler were to do the work of a blacksmith, what great harm, after all, would result?

Nevertheless, Plato saw the possibility of applying the principle of selection even to those engaged in industry. It is said, for instance, in *The Republic*,[1] that "there are diversities of natures among us which are adapted to different occupations"; again, that "all things are pro-

[1] Book II., 370.

duced more plentifully and easily and of a better quality when one man does one thing which is natural to him." [2] Plato even goes so far as to suggest that, in a well-ordered state, retailers or distributors should be those who are weak in body and therefore of little use for any other purpose.[3] And *justice*, a discussion about the nature of which led to the attempt to picture an ideal state, is defined finally as "every man doing that for which he is fitted by nature." [4]

Now, the idea of selecting *workers* on the basis of natural fitness was, to Plato, not only relatively unimportant: it was in his day altogether impracticable. Indeed, this idea has been impracticable almost down to the present, and for two reasons. Firstly, it is only in modern times that industry has become so organised along the lines of specialisation as to make the application of the idea generally worth while. Secondly, it is only very recently that there has been sufficiently precise scientific knowledge to make the enterprise actually possible. To-day, however, largely through the time and attention lately devoted to psychology, and especially through the results obtained in psychological laboratories, it is to some extent possible, for instance when apprenticeship is being entered upon, to carry into practice this old idea of selection of industrial workers according to natural fitness.

[2] *Ibid.* [3] *Ibid.* 371. [4] Book IV., 433.

Now, when psychology is applied to industry, we have a case of applied science. The war, among its many unexpected effects, seems to have brought about a popular realisation of the material advantages to be derived from the systematic application of science. It taught us many economic facts of which we were ignorant before; and seemed to show that the systematic application of science to industry was chiefly responsible for Germany's considerable industrial development. The war situation forced people to ask what exactly was meant by and what was possible by means of applied science. Even the conservative mind began to consider whether it would not be advisable, in view of the probable immense consequent advantages, to apply science systematically and persistently.

There has, of course, long been a popular idea that science is of great practical utility. As evidence of this fact, we point to the steam engine, the telephone and telegraph, electric and "motor" cars, gas for cooking and heating, and so on. But this popular idea has rarely, if ever, been associated with the conviction that science might be, and if possible ought to be, applied to every department of life. When people now talk of the possibility of applying science to industry, they most often seem to be thinking of the application of special chemical knowledge to the dye industry, or other special chemical knowledge to metallurgy, or still other special chemical knowledge to brewing or baking. It is usually

some chemical knowledge that is to be applied to something. Next in order of popularity is probably the idea of extending the applications of our knowledge of electricity; for instance, there is the idea that electricity might be advantageously used as an alternative to gas for heating as well as cooking purposes. And, sometimes, one meets the idea that our knowledge of physics might perhaps be applied much more extensively than it is at present; for instance, in connection with grain elevators, and wherever heavy lifting is required. There is, however, no general opinion directed towards the systematic application of scientific results everywhere possible throughout life; and there is scarcely any conception of applied psychology, or of the results which might be obtained from the application of psychology to industry. This last fact is intelligible enough, since psychology is a new science. Even to-day psychology is sometimes denied the title of "science" and an independent status. Although this treatment is disappearing, it is still occasionally met with; and I shall therefore briefly indicate how, for the purpose of these lectures, psychology may be conceived.

There are numerous definitions of psychology. For instance, psychology is defined as "*the description and explanation of states of consciousness as such*"; again, as "*the positive science of human conduct or behaviour*." We may here accept the etymological definition of psychology *as the science of mind.* By the term *science* is

understood, simply, *knowledge* that is *accurate* and *systematic*. By the *science of psychology*, then, is meant *accurate and systematic knowledge about the mind*. It may be said that this is not very enlightening unless we already know what the mind is, and it may seem obvious that we do not possess complete information on this point. We know enough, however, about the manifestations of mind, to make the above definition useful. That definition is sufficient to direct us to the sphere in which the knowledge that is called psychological is to be obtained. People, generally, are agreed that whatever the mind in its completeness may be, processes of *perceiving*, *attending*, *memorising*, *desiring*, and *willing*, for instance, belong to it; and that, in getting knowledge about these processes, we are getting knowledge about the mind. The etymological definition of psychology is thus intended *to direct us*, when we wish to obtain psychological knowledge, *to the kinds of processes usually held to be mental*, such as those just mentioned.

An important point, however, must not be overlooked. Psychologists believe that the physiologist who says there is nothing to be observed in the living organism except physiological matter—a rare statement nowadays,—is wrong; but they insist nevertheless that what they call *mental* stands in a very intimate relation with what is called *physiological*. Study of mind can scarcely be satisfactory apart from study of the body. *Human psychology may thus be*

conceived as such accurate and systematic knowledge about the whole individual, mind and body, as will enable us to understand the features and operations of the human mind. For the purposes of these lectures, it is most important that the close relation between the body and the mind should be recognised, as it is by bodily movements that all industrial processes are carried out. The study of certain aspects of bodily movements is consequently to be included within the scope of psychology.

From very early times there has not been lacking an interest in the human mind, especially in the emotions and feelings. There have always been mind-observers. Early observations of mental facts, however, were not usually systematic, nor were descriptions of such facts made in scientific terms. Attempts were sometimes made *to analyse and to classify* mental facts, sometimes *to describe* the processes of perceiving, attending, desiring, judging and willing. Only in recent years, however, did psychology become a formal science. When the attempt to make it such began, the psychologist first limited his attention to observation and description of his own mental processes. Lately, the scope of psychology has very much widened, and the subject now includes a comparative study of minds,—that is, the psychologist no longer analyses and describes his own mental processes only, but endeavours also to compare the mental processes of different minds. As a result of this kind of observation it

has become known that the minds of different persons shew marked differences in many respects. This is hardly to be wondered at when we recall the fact that people so frequently misunderstand each other. In dealing with this and other mental facts there has arisen the modern psychological laboratory. The first of such laboratories was instituted in Germany about forty years ago. They are now to be found in all civilised countries, though Germany and America have built them most extensively. There is a number of them in England and Scotland.[5]

The psychological laboratory provides convenient opportunity for the study of various mental processes. In it the psychologist examines the elementary sensations, association of ideas, attention and fatigue, etc. It gives specially good opportunities for investigating diversity between minds. Different persons are put into precisely the same set of circumstances, and the attempt is made to discover and analyse the differences between them which then come to light. Numerous experiments of this kind have been made, aiming to discover differences between persons concerning memory, attention, fatigue, and so on. This branch of experimental psychology has been called the *Psychology of Individual Differences*.

The combined efforts of modern scientific

[5] One was instituted at the University of Sydney, New South Wales, in 1918.

psychologists have resulted in the collection of a large body of facts about the mind and its relation to the body. Thus we now know a great deal about the differences which there are between persons in respect, for example, of rapidity of perception, suggestibility, emotions, co-ordination and precision of movements, and so on. In accordance with the idea of systematically applied science, what we have to ask is whether any of this psychological knowledge can be applied.

In addition to some attempts which have been made to apply psychology to industry, this science has already been applied to three important spheres, namely, to Education, to Law, and to Medicine. These applications are of considerable interest, and some account of them will therefore be given before we proceed to our more particular question of the application of psychology to industry. What we should endeavour to see is that industrial psychology is part of a wide movement for the application of psychology to life.

§ 2

Applications of Psychology to Education, Law, and Medicine

(*a*) If we begin to reflect upon possible applications of psychology to Education, we see

at once that they cover an extensive field. There is probably no educational problem to which some psychological knowledge or other is not relevant. Educational problems are, of course, multitudinous. In the past, they have often been "solved" by the *obiter dicta* of capable thinkers, but perhaps *most* often by persons in authority who believed that the educational institutions in which they themselves had grown up could not be far wrong.

A movement to base opinions about educational methods and practices upon experiment has recently assumed considerable size and force. One of its earliest expressions appeared in the last decade of the nineteenth century,—Dr. J. M. Rice's experiments upon spelling. By making experiments on the children attending a large number of schools, Rice shewed that much of the time ordinarily spent upon Spelling Drill was wasted, in the sense that it had no good effect upon spelling capacity. The results he obtained in these experiments, together with others of a very interesting character, were published later in a book entitled *Scientific Management in Education*, the name of which well indicates its spirit. Cornman and others later carried out experiments confirming Rice's conclusion that, in the elementary schools, more than fifteen minutes per day spent upon Spelling Drill is waste time. Such experiments as these may be called *direct* educational experiments; and in them there may be little application of psychology.

On the other hand, there are what may be called *indirect* educational experiments. These consist in investigating elementary processes of mind and in using the results thus obtained for the construction of good educational methods. *Indirect* educational experiments are, therefore, *application of psychology to education.* The questions that may be raised in this sphere are very numerous. For example: What is the best kind of situation for schools? Should schools be in the noisiest parts of cities, near main thoroughfares and within easy hearing of electric trams, or should they be as much as possible secluded from noise? How many hours per day should a growing child be allowed, or urged, to study? Does the fatigue operative in connection with afternoon teaching and learning make such teaching and learning largely valueless? Should girls be given the same education as boys, and should they be required to study as many hours per day as boys? What is the best arrangement for rest intervals throughout the school day? Is it not economically wasteful to have teachers in charge of classes of more than fifteen children? And so on. All such questions are instances of the general question: By what methods can the education of the child, in accord with a certain ideal, be best effected? To many such questions psychology may some day provide an answer; there are few to which it has an unassailable answer to offer now. One of these latter questions may be referred to briefly. This

question is: What is the best method of memorising?

In the ordinary course of education, a child is required to memorise, to a greater or less extent. Now, it is a natural thought that some methods of memorising might give better results than others. Numerous psychological experiments have shown that this is so. Suppose, for instance, that you want to learn by heart a poem consisting of six 4-line stanzas. Ordinarily, you would probably begin by trying to learn, first, the first line of the first stanza. You would read this over and over until you could repeat it "not looking at the book." You would then proceed to the second line and adopt a similar method, then to the third, and after that to the fourth. You would then probably try to repeat the whole four lines together. This might give you some difficulty at first, but after a few readings you would probably be successful, and would then proceed to the second stanza, which you would treat in the same way as the first; and so on until you could repeat the whole poem, special attention being paid finally to learning the sequence of the stanzas.

But it would be possible for you to proceed upon an entirely different method. Instead of repeating one line until it was "impressed on the memory," you might begin by reading the whole poem. If, after one reading, you tried to repeat it from memory, you would probably fail. You might then read the poem through

once more. The attempt to repeat it from memory would probably still fail; but you might continue reading the whole poem through, until, finally, you could repeat it from memory.

Thus, there are two methods for memorising anything which consists of parts. One is to memorise a part at a time, proceeding part by part, until you have memorised the whole. This is called the "sectional method." On the other hand, you may take the whole as a unit, and repeat this again and again until your memory has grasped it. This is called the "entire method." It may seem to you that this latter method would not yield very good results. It has been found, however, that learning by this method is, within certain limits, quicker and surer than by the sectional method. Less time is required in order that something may be correctly repeated once, and more is retained in the memory after a long interval of time.

If, then, we desire to apply knowledge derived from psychological science to education, we can, in giving memory tasks to children, shew them how to proceed if they are to save time, and acquire a relatively lasting grasp of any matter which needs to be memorised. This specific piece of knowledge is now much employed in schools. It is one of many facts discovered in the psychological laboratory which have a bearing upon education.

(*b*) The application of psychology to Law is also concerned with many large questions. Such, for example, is the character punishment is to assume if it is to be really beneficial to the community by acting as a deterrent to crime, and if, at the same time, it is to be reformatory. The chief point at which psychology has been applied to law is in connection with evidence. The general question here is: Can psychology give any help in deciding what evidence can be taken as trustworthy, and what evidence must be excluded as untrustworthy? In the attempt to give an answer to this question various psychological experiments have been undertaken, and a mass of facts has been collected. It has been found, for example, that racial traits have a bearing upon evidence, that of certain races being, in general, much more worthy of credence than that of others. Again, it is considered probable, at least, that differences of sex result in differences in the character, and, sometimes, in the trustworthiness of evidence. Similarly, differences in age and education are of importance. A child cannot be expected to grasp truly a situation in which the actors are adults with adult passions and motives. Similarly, we cannot expect that an old man's perceptive faculties are as good instruments as those of a young healthy adult. Such considerations are more or less general, and it may be difficult to see how they can be applied to actual cases. This, however, is not always so.

There is a more or less common opinion that the evidence of a child must be very trustworthy; for, it is argued, the child is unacquainted with the evils of the world and is more or less innocent. That the child is not likely to give false testimony deliberately is probably true. We have to remember, on the other hand, that a child's mind is only the mind of a child, and is more liable to be misled in its judgments of fact than the mind of a man. Consequently, to convict a person of a serious crime upon a child's evidence must always be risky, unless a very close examination of the evidence be made. A case in point will make this clear.[6]

In the year 1910, a certain district in Belgium was shocked by the commission of four separate similar crimes within a single month. The last of them was the murder of a nine-year-old child, Cecile de Bruycker, on Sunday, June 12th, 1910, in daylight, and within a short distance of her home. Her movements were known up to four o'clock, when she was playing with two other little girls; and the crime was committed between four and five o'clock. When she did not return home, her mother went to the homes of her playmates, aged ten and eight, who both, on being awakened from sleep, stated: "Cecile

[6] This case is given by M. Varendonck in *Archives de Psychologie* (XI., July 1911, pp. 129-171); summarised by G. M. Whipple (*Journal of American Criminal Law and Criminology*, 1913), and by J. H. Wigmore (*The Principles of Judicial Proof*, 1913, pp. 521-524).

played with us, but we haven't seen her since." The little girl of ten was again roused by the police commissioner at 3 a.m., and, after being questioned, she led him to the place where she last played with Cecile. A short distance from this spot the child's body was discovered, and *then* the little girl added that "a tall dark man with a moustache" had enticed Cecile to accompany him. She said that she herself had followed, and soon afterwards found her friend dead in a ditch, but was afraid to tell and so went home to bed.

Two days later an anonymous letter reached the police stating that a certain man, the father of one of the two children mentioned, must be the murderer. In a long examination by a magistrate, the two children gave further details about the man they had "seen." After the arrival of the anonymous letter the man mentioned in it was arrested and nearly lost his life from an infuriated mob on his way to prison. Before the trial the little girls stated, in answer to questions, that they *knew* this man had killed their playfellow.

In the trial which followed, in January, 1911, the chief reliance of the prosecution was upon the testimony of the two little girls. Counsel for the defence thereupon engaged a number of psychologists to undermine the juvenile testimony. M. Varendonck, the chief psychological expert, had conducted various experiments upon school children, putting to them *questions of the*

nature and form of those put by the authorities to the two girls. This he laid before the court, together with a general account of work done by experts in the study of the psychology of testimony. He concluded that the girls had positively not seen the murderer and that their testimony was worthless. Some of his experiments on school children are worth quoting. Eighteen 7-year old pupils were asked the colour of the beard of one of the teachers in their building: 16 answered "black"; 2 did not answer; the man had no beard. Similar results were obtained from older pupils. In every case the children fell victims to suggestive questions. Twenty-two pupils gave written answers to the following: "When you were in line in the yard, a man came up to me, didn't he? Write his name on your paper." No man had come up; but 7 of the 22 wrote a name. The experimenter then continued: "Was it not Mr. M—— ?" to which 17 of the 22 pupils now answered instantly, "Yes." Varendonck concluded from his experiments that the only correct statement made by the two little girls was their first one, that they had not seen their friend since playing with her. The psychologists' testimony was received with outbursts of wrath by counsel for the prosecution, who publicly ridiculed it; but the jury was profoundly impressed and the accused was acquitted.

There has been a tendency to suppose that if a

witness does not speak the truth he must be deliberately trying to deceive. The general opinion has been that, apart from slips of memory, any honest straightforward man who should be placed in the witness-box would give a faithful and trustworthy account of his experience. But experiments on evidence make it clear beyond all possible doubt that error is a *normal* feature of any person's testimony. No matter how honest a witness may be, his evidence will almost certainly contain some incorrect statements. In establishing this fact, experimental psychology has been of considerable importance in helping to evaluate the worth of evidence in certain cases.

The Belgian case suggests another thing also, namely, the importance of eliminating from the form of questions anything that might mislead a witness. There is, of course, a general rule against the use of leading questions in cross-questioning, although this rule is set aside in certain instances, as when a witness is hostile, or when the matter upon which he is being examined is very complicated. But there is not yet any adequate knowledge as to when a question is a leading question, or as to how relatively misleading different leading questions may be. It appears, for instance, from the results of experiments, that the question, *Did you see* a gun in the man's hand ? gives *inaccurate* answers less frequently than the question, *Was there* a gun

in the man's hand ?[7] From all which it is clear that the possible sphere for the application of psychology in law is of considerable extent.

(*c*) Proceeding now to the application of psychology to Medicine, we must distinguish between actual and possible application. The field of possible application of psychology seems here very large, and includes problems concerning which psychology has at present no advice to give. Certain of the ailments to which man is subject are, of course, purely physical. If a person breaks his leg or collar-bone, psychology leaves him alone ; his health is to be restored by accepted methods. If, on the other hand, a person shows signs of being a sufferer from consumption, it is not so clear that means of curing him are physical only. If he continues in a state of depression, for example, he will probably mope indoors a great deal, and his malady may grow ; but if a cheerful attitude can be induced in him, he may be led to seek companionship in the open air, and his health may thus improve. In such a case, psychology says that we must do what is possible to remove depression. " Medicines " alone will be insufficient.

Consumption, however, is an illness in which,

[7] *Cf. British Journal of Psychology* (*VIII.*, 3, 1916 ; pp. 351-389).

it might be held, psychology can do no good; and, at the least, it must be admitted to be on the border line between the sphere in which psychology is applicable, and the sphere in which it is inapplicable. There is, however, a certain kind of illness which perhaps a knowledge of psychology alone can remove. Such illnesses may be referred to, generally, as nervous illnesses.

The extreme case of this kind is that of the lunatic. Of lunacy there are various degrees and sorts. Some people are definitely insane, while others are just on the border-land between sanity and insanity, or perhaps, sometimes sane and sometimes insane. And there are many persons who would not be called insane at all, but are by everyone regarded as peculiar. Also numerous instances occur of obsessions and various forms of what has been called double-personality. Finally, there are cases in which some part of the body operates abnormally, with no apparent physical cause.

Now certain psychologists have elaborated a theory of the constitution and growth of the mind and its relation to bodily functions, in accordance with which such illnesses can, in the first place, be *understood*. It is claimed by these psychologists, who are not infrequently men with medical degrees and practising physicians, that, by means of their psychological theory, they can explain precisely what an obsession, for example, or a hysterical symptom, is; and that by understanding how it is related to the mind as

a whole, a cure can be effected through purely psychological means. The theory of the mind which is adopted in this connection, and the theory of the relation of hysterical symptoms, for example, to the mind, are too elaborate and involved to be explained here; but I will illustrate by an example the kind of case in which they are used.

The Austrian psychologist Freud claims to have cured many cases of hysteria and nervous breakdown by psychological treatment. The American Dr. Brill, one of his best known and most successful disciples, describes a number of cures by purely psychological methods. One of these [8] relates to a man of thirty-three, a druggist, who suffered from an acute form of what is called "dirt phobia." This had begun by frequent washing of hands; but at the time the man came to Dr. Brill in 1911, it had so expanded that he was afraid to touch almost anything for fear of transmitting some poison or filth to himself or some other person. He was entirely incapacitated by his neurosis; became excited with anxiety about touching dirt; was especially worried by poisons, and, as a drug salesman, became useless in his business. He would not use matches, nor pass a paint shop, nor touch a metallic door-knob, for fear of some "canker," as he called it. In vain had he tried all kinds of

[8] A. A. Brill's *Psychanalysis* (1914, 2nd edition, pp. 131-136). Dr. Brill gives numerous other cases also.

orthodox treatment,—medicines, rest-cures, sanatoria. It was feared he must be confined in some asylum, and his health was utterly undermined when he came to Dr. Brill for treatment. After five months he was discharged as cured and has since had no return of his phobia. Brill gives in great detail his method of treatment, which began by attempting to trace back by what is called "free association of ideas" the repressed and unconscious motives which led to the man's phobia.

The point to be emphasised is that the cure of this man was effected solely by an application of psychological theory. For some time past, a method based upon this theory has been used with much success in certain hospitals in England in treating soldiers suffering from shell-shock. It is interesting, too, to note that the British Government appointed a psychologist with the official title of Consulting Psychologist to the British Armies in France.[9]

[9] The holder of this office was Dr. C. S. Myers, Director of the Cambridge Psychological Laboratory.

§ 3

The Definition of Industrial Psychology

The aim of the application of psychology to any department of life is determined by the already existing general aim of that department. The aim of any department is in no way altered by the application of psychology to it. Thus, the aim of education is to train youth so that a certain standard of knowledge and character may be attained: the application of psychology to education simply attempts to further this aim. The aim of legal procedure is to dispense justice in accordance with existing law: the application of psychology to law simply means that, in modifying present legal procedure by our psychological knowledge, the dispensation of justice may be rendered more precise. The aim of medicine is the health of the sufferer: the application of psychology to medicine simply means that psychological knowledge in certain instances helps to further this aim. Generally speaking, the same is true of industry. Whatever be the aim of industry, the application to it of psychological science in no way alters that aim. The most it can do, and what in general it tries to do, is to render the aim of industry more easy of attainment. This point needs special emphasis. I therefore wish to repeat that *all that the application of psychology to industry means essentially* is that the aim of industry, whatever this is, may be effected more easily.

If we enquire what the aim of industry is, we must take a comprehensive glance at society. In a sense, industry has no aims, for, strictly speaking, aims exist only in the minds of persons. In speaking of the aim of industry, what is meant is its function in the social fabric. We observe, then, that industry is that part of social life whose function is to provide civilised man with the material goods that his conditions of life demand. From the point of view of *society as a whole*, the aim of industry is to supply such goods in the most economical manner possible. Further, from the point of view of those members of society *engaged in industry*, whether employers or employees, the aim of industry is to perform its task with the *least possible waste*, so that the greatest possible returns may come to them. Immediately we centre our attention upon an actual industrial plant, it seems obvious that the interests of both employer and employee are bound up with economical production. That there should be as little *waste* as possible, whether of individual effort or of capital, seems an obvious consequence of the aim of industry, from whatever point of view it be regarded. As a result of such considerations as these, we might, tentatively, state that the general aim of industry is to produce the material goods required by civilised man in the most economical manner possible.

The accomplishment of this aim is by no means easy, and involves numerous variable factors,

more or less independent. And, at least for the present, psychological science touches industry on one side only: psychology sees immediately before it the possibility of cheapening the cost of production by its application to the labourer and to his methods of work. The *immediate* question presented to industrial psychology is this: can psychology cheapen production by aiding in the elaboration of good methods of work, on the one hand, and by deciding, on the other hand, which individuals are specially fitted by nature for this or that kind of employment? Put quite generally, then, *the immediate aim of industrial psychology is to utilise psychological knowledge* (a) *in selecting workers on the basis of natural fitness and* (b) *in constructing good methods of work, for the purpose of obtaining from any expenditure of human energy or effort a maximum production.* This general definition will become clearer as I proceed in later lectures to give illustrations of attempts to carry out its main ideas. The first part of it, (a), may seem obvious enough; but the second part, (b), may be confused with ordinary machinery inventions. This confusion, however, may be easily removed.

Suppose there is some extensive piece of machinery that is operated by steam, the power being applied by the moving of small levers. If an engineer were to modify the machinery while leaving the levers operated by the workman the same, he might increase output, but would not be applying psychology. If, however, he were

to rearrange the system of levers, changing the positions of some and perhaps doing away altogether with others, these changes being made so that the workman could more easily control the machinery, he would be applying psychology to industry, although the particular psychology applied might here be very crude. It may be useful to consider a more concrete case. I shall therefore discuss certain features of typewriting machines.

It is necessary to preface my remarks here by saying that, when science is applied to industry, it is at times difficult to decide what part of the applied science may rightly be called psychology. I say this because I do not wish to give the impression of meaning that everything connected with typewriters is an application of psychology to industry. This, of course, would be a mistaken idea. Hence, in what follows I shall specially emphasise the psychological points.

The industrial aim which the typewriter is intended to realise is, broadly speaking, rapid writing with the characters generally used in print. It is obvious, as a principle, that any instrument used in the attempt to accomplish this aim must be adapted to a man's psychophysical constitution. It is of interest to note how this principle has been worked out. At first, men laboriously printed each letter with some pointed instrument. Later, they got the idea of separate letter stamps, which could be used one after another. For the printing of any one

letter, the stamp was, of course, much quicker than the pen; but, in printing words and sentences, a considerable amount of time would be lost in selecting the letters needed at any moment, and in picking up and putting down the stamps. Thus arose the idea of arranging the different letter stamps in a machine, and hence the typewriter.

The next thing to be mentioned is perhaps more than obvious. This is that even the earliest and crudest forms of typing machines had to shew a general adjustment to the human operator. For instance, the keys had to be arranged in such a way that they could be pressed by human fingers. This, I say, is perhaps more than obvious; but it is the principle which is of importance. It soon became clear that some of the letters of the alphabet occurred more frequently in ordinary speech than did others. It became clear, also, that certain fingers were naturally more fitted for pressing keys than other fingers. These two facts led to the construction of different types of keyboards; and in this we can see a definite attempt to adjust the mechanism to the man.

We come, however, to a more definitely psychological point. This concerns the method of using the typewriter. Given the keyboard most suitable to the relative frequencies of the letters and to the formation of the hand, what method should the typist adopt in operating? A

typist might, for instance, use only one finger in typing, pressing with it one key after another,—an obviously poor method. It would not be much better if one finger of each hand were used; or even if several fingers of the right hand and the index finger of the left were employed. As opposed to such haphazard methods, a typist might learn a method of operating involving the use of all the fingers of both hands. Such a method would be difficult to learn, but, when acquired, would realise the industrial aim of typewriting better than any other: that is, by it the writing would be performed with the greatest possible speed. Of course, it would need to be based upon the possibilities of co-ordination between the movements of the fingers and the relation of these to the mind.

From what I have said so far, it is clear that appropriate knowledge, which would be largely psychological, could determine the best method for operating a typing machine. One of the recent developments in learning to typewrite is the *touch* method. Learning by this method takes longer than by *sight and touch* together. It is evident, however, that it would be a great advantage to the typist if she need never guide her fingers by sight, but keep her eyes on the manuscript from which she is copying. Whether the extra speed thus gained would, or would not, be discounted by an increase in errors, it is difficult to say, but the fact could be easily determined. It is probable that individual

differences would be evident here, some persons doing their best work with the *sight and touch* method, others with the *touch* method. It must be remembered also that fatigue has to be taken into account. It is probable that here, as elsewhere, one method is relatively more fatiguing than another. This could be determined by experiment; and when this had been done, we could decide upon the relative merits of two methods of typing by considering the speed and accuracy obtained, and the fatigue produced, by each.

That the same method of operating a typewriter may not be the best for all typists is indicated by a further fact. In some machines the writing is visible, while in others it is not. Manufacturers of machines with visible writing make much of this feature. As a matter of fact, it is almost certainly not universally an advantage, being of most value to the amateur, and to the expert typist practically irrelevant. To some typists, the seeing of what is being written is a distraction which impedes their rapidity, and not an assistance.

Let us return to the question of fatigue. We may discover that the muscle fatigue produced by the otherwise best method of typing is excessive. I am not suggesting that this is so, but merely putting a hypothetical case. Supposing that we make this discovery, we shall, of course, search for devices to lessen the muscle fatigue.

How shall we set about this search? Now, by whatever method the fingers be used, the mere pressing of keys is essential to typewriting. And it is obvious that the amount of pressure necessary to make one imprint with one key might possibly be varied considerably.

According to the advertisements of certain manufacturers, some typing machines require "a muscle pressure of from 12 to 15 ounces" for each imprint, while others require (for each imprint) "a muscle pressure of only 5 ounces." I shall quote from an advertisement. "With the lightest running typewriter it takes about 5 ounces of pressure to make one imprint. That is, every time a stenographer depresses a type-key she exerts a pressure force of 5 ounces with one finger. With 70 type spaces in a line she exerts a pressure of 350 ounces for each line. In writing an average letter, therefore, of 40 lines, the stenographer exerts a force of 875 pounds, considerably over one-third of a ton weight. Since typewriters vary in touch from a minimum of 5-ounce key pressure to from 12 to 15 ounces, think what a difference, therefore, in physical demand upon the stenographer is just this one feature alone.

If you will consider, also, the physical force required by shift key and carriage return—one-half pound for each depression of the shift key and three pounds to move the carriage back against the spring tension—this brings the total

expenditure of energy up to about 25 pounds per line.

In the course of an average day's work of, say, fifty 40-line letters, the variation in the force required to operate two different machines may amount to an aggregate unnecessary and avoidable expenditure of physical energy on the part of the operator equivalent to the lifting of a dead weight of fifty times 1,200 pounds—or 30 tons a day"!

This advertisement was written, of course, to sell the 5-ounce typewriter, and the language employed (therefore) approximates to that of everyday life rather than to that of science. To make the comparison between the "12-ounce" and the "5-ounce" machines in scientific, that is, in definite, terms, it would be necessary, although, no doubt, not difficult, to calculate the "measures" used,—such as so many "ounces pressure,"—in, say, footpounds: a footpound being the amount of energy required to raise one pound a height of one foot. At the same time, the advertisement probably indicates, though with perhaps some exaggeration, an actual and important fact: namely, that the use of certain typewriters involves a greater expenditure of muscle energy than does the use of others. This fact becomes more suggestive when it is recognised how light is the touch required to operate the linotype machines now in use in all large printing establishments.

It should be noted, however, that the mere use of the "5-ounce" typewriter,—even granting what is claimed for it,—would not *guarantee* the saving of muscle energy suggested, for the typist using it might strike the keys more vigorously than was necessary, thus exerting much effort wastefully. It would be a part of the function of applied science to discover just what pressure should be exerted by a typist on the best sort of machine, and then to teach her to make precisely that pressure and no more. It is obvious that a device which will do away with the need of expending a considerable amount of muscle energy in each day's work must be an effective factor in decreasing fatigue and its bad consequences.

What I have said about the typewriter is intended to illustrate, to some extent, the proposed definition of industrial psychology. It is now possible, however, and indeed desirable, to suggest an alternative form for that definition. The fact is that, in working out a definition of industrial psychology, we need to have something theoretically fixed, or "constant." In actual industrial processes nothing is fixed except temporarily; all the factors involved are "variables." In order to understand the immediate aim of industrial psychology, however, we may theoretically make either one of two variables "constant."

On the one hand, we may suppose that the

amount of goods to be produced, or, in other words, *the industrial task*, is a known and fixed quantity. This would, to some extent, correspond with what actually happens in life, where we want houses to live in and clothes to wear. There would be no complete correspondence, because there is nothing fixed about our wants. *On the other hand*, we may suppose that the amount of human energy to be expended industrially is the fixed quantity. It is upon this second supposition that our previous definition of industrial psychology is based: that is, assuming that a certain amount of human energy is to be expended in industrial processes, industrial psychology, I said, is the attempt to apply psychology so as to get a maximum production from it. If, however, *the amount of production* be the fixed quantity, as is the case on our first supposition, we cannot, of course, endeavour to increase it; but we may then state the immediate aim of industrial psychology to be *the attempt to apply psychology so as to get the fixed quantity of production from the minimum expenditure of human energy.*

These forms of definition broadly correspond to the points of view from which the employer and the employee regard all applications of science to industry. The one asks: How can output be increased? the other: How can expenditure of effort be lessened? In practice, these points of view frequently lead to conflict; but theoretically they offer no difficulty to the com-

prehension of the question: What is industrial psychology? And the suggestions offered by industrial psychology can be carried out by one who regards the question from either point of view.

§ 4

The Relation between Industrial Psychology and Speeding Up

I shall now attempt to make clear the difference between industrial psychology and speeding up. A recognition of this difference is very important, firstly, because it is generally agreed that speeding up is bad and labour's hostility to it perfectly justified; secondly, because, in one of the forms in which I defined industrial psychology, there is a reference to increased production: and there is a common misapprehension that increased production involves speeding up.

I define speeding up as *the attempt*, by offering incentives of one kind or another to the will, *to induce operatives to expend more than the greatest reasonable amount of energy in a given time.* To make this definition of value, we must be able to state what is the "greatest reasonable amount of energy" that can be expended in a given time,

or how we are to arrive at some measure of this amount. I think that, in this respect, we have to depend upon the good sense and honesty of those actually employed in any work. Any honest body of workmen will know when they are going too fast, and, finally, the workman's word must be accepted as to what is a reasonable working rate. If you doubt his word, put yourself in his place for some weeks, and demonstrate to him, practically, that he is wrong: any other method is hardly reasonable. While this is so, there are certain distinctions that will enable us to see, to some extent, when there is likely to be speeding up and when there is not; and a recognition of these distinctions will help in making plain the difference between speeding up and industrial psychology.

Let us suppose that a reasonable working day is fixed at eight hours. There are then four important variable factors associated with a day's work. These are:—

(1) The Method of work.
(2) The Energy expended.
(3) The Output.
(4) The Wages.

Of these variables, the employer desires primarily an increase in the third, output, while labour desires primarily an increase in the fourth, wages. To some extent, also, both are interested in the second variable. Labour not unnaturally would be pleased to ensure a decrease

in the value of this variable, while the employer often thinks that, if this value could only be increased, output would probably be increased also. Until recently, neither the employer nor the employee gave much attention to the first variable factor, the method of work.

Let us suppose, now, that an employer attempts to increase output. What forms could such an attempt take? Broadly speaking, and neglecting details, an employer might proceed in one of three ways. (1) He might, firstly, attempt to effect his ultimate aim by increasing the efficiency of his machinery. This method I shall not discuss, as it is, for our present purpose, irrelevant to the subject of speeding up. (2) Secondly, he might adopt the traditional method of offering, in one form or another, an increase in wages, on the understanding that, in return for this increase, his employees would work harder. (3) Thirdly, he might attempt to construct better working methods than those in practice. If he adopted this third procedure, he would probably need to offer an increase in wages as an inducement to his men to use the new working methods; but it is to be noted that in this case the rise in wages is offered on the understanding that a new method of work will be used, and not that a man will work harder. Of course, an employer might *combine* the second and third procedures; he might construct better working methods, and, at the same time, offer an increase in wages sufficient to ensure *both* the use of these methods

by the men and a greater intensity of work from them.

I shall consider, first, the use of the more traditional procedure, namely, offering a rise in wages in return for harder work. We may suppose that in some particular case this procedure has the effect desired by the employer, namely, that it produces an increase in output. Now, if, prior to the introduction of this method, the men were expending the greatest reasonable amount of energy in any given time, the offer of higher wages for more intense work involves speeding up. The workers who endeavour to win the increase in wages will constantly experience the unpleasant feelings which we denote by such terms as "being driven" or "being rushed" or "working against time." This result may, of course, be brought about in other ways than by a mere increase in wages: the more intense work may be elicited by playing upon a workman's fears, in various ways. Generally, however, it is the effect of offering the workman a reward of some kind or other, as an incentive or spur to the *will*, so that more than the greatest reasonable amount of energy is expended in a given time. Here, then, we have the essence of speeding up.

Consider, secondly, what happens when an employer attempts to construct, and having constructed, to bring into use, better working methods. It is conceivable that such methods might involve no greater expenditure of energy

in a given time than those already in practice. Theoretically, it is obvious that working methods might be varied indefinitely while the expenditure of effort involved remained "constant." And, in the cases of numerous recent attempts to construct better working methods, no greater expenditure of energy has been involved. Indeed, in some of these, the expenditure of energy required in a given time from operatives seems to have been less than that required by the methods previously in use,—notwithstanding the fact that the new methods effected a greatly increased output. Hence, whenever attempts to increase output by the construction of new methods of work do not require more than the greatest reasonable expenditure of energy in a given time, there is no speeding up.

It is now possible to understand and dispose of a common confusion. It is often thought that, whenever the labour of an individual operative yields an increase in output, speeding up must have been resorted to. So far from this being necessarily the case, it generally happens only upon two conditions, namely, that, prior to the increase in output, the operative was expending in his labour the greatest reasonable amount of effort in any given time, and that better working methods were not introduced. It is important that no confusion should remain upon this point, and I shall therefore attempt to illustrate it concretely.

In a certain American establishment the

"task" method of work and pay was in operation. Task work may be considered as piece work, with this vital difference, that any given task must be performed in a given time. Upon task work a man must work at a definite rate, whereas upon piece work his rate is theoretically dependent upon his inclination. In this American establishment, the workers were paid a bonus of 25 per cent. of the ordinary wage rate if they accomplished their tasks in the set times: that is, if the time set for a given job was one hour, the man who finished the job in an hour was given an hour and a quarter's pay. It is natural to suppose that, in these circumstances, the set times were very short; and this was actually so. The task and time setter was paid a bonus based upon the number of workers under his charge who *failed* to earn their full bonuses. Thus, his efficiency reached 100 per cent. when every one of these workers *failed* to do his tasks in the times allowed for them. On the other hand, the foreman was paid a bonus based upon the number of workers under him who "made their tasks" in the set times. His efficiency reached 100 per cent. when all his workmen "made their tasks." The situation, then, was this: the workman was given a bonus as an incentive to expend intense effort in accomplishing a task in a set time; the foreman was paid "blood money" to drive the man if he became slack; and the task and time setter was also paid "blood money" to set the times so short that "the making of the tasks"

involved an expenditure of more than the greatest reasonable amount of energy. It is not difficult to imagine the feelings of the workers in this establishment. It must be added in fairness that this is an extreme instance of speeding up.[10]

Concrete illustrations of the principle that increased output does *not necessarily* involve speeding up will be given in succeeding lectures; but I shall here conclude by putting a hypothetical case which may help to fix the foregoing distinctions in the mind.

Let us suppose that, some centuries ago, a man, working in a great library, comes upon a very rare book, and desires a copy of its contents. For different reasons, he is unable to make the copy himself, and so employs someone to do it for him. Suppose that the only person to be got for this work is a man whose writing is limited to printing in ordinary capitals. This person is regarded with some dismay; but, as there is no one else to do the work, he is engaged. The copy of the book is required as soon as possible. Printing its contents in ordinary capitals, however, will take twelve months, let us say. What, then, does "the employer" do? Theoretically, and supposing he possessed the knowledge, he might, at least, do one of two things: offer the man greater reward for increased effort, or teach

[10] This case is given in J. P. Frey's *Scientific Management and Labour* (p. 16).

him a better method of copying. Now, if the printing of the book in capitals requires twelve months when the man is working at the greatest reasonable speed, offering him an increase in wages for working harder is speeding him up; by this means the book might be copied in, say, eleven months. On the other hand, suppose that his employer first teaches the man ordinary script: then, having learnt a new method of copying, the man might finish the book in six months; or, again, he might be taught a system of shorthand which would allow him to complete it in three months. Is the man speeded up because a piece of work, which would occupy twelve months if one method of working were adopted, is done in six months, or even in three months, by another method? It is obvious that this need not be the case. The man, indeed, might work more comfortably and at a more reasonable rate when using the quickest of the three methods mentioned. A reporter is not speeded up because he uses shorthand; he would be speeded up if he did not.

From this analysis, and from the definitions of industrial psychology and speeding up that have been given, it seems clear that, practically, *there is no similarity whatever between industrial psychology, as above defined, and speeding up.*

Lecture II.

MENTAL FACTORS RELEVANT TO INDUSTRY

§ 1

Facts to be Discussed

In this lecture I shall discuss *some* of the mental factors which seem especially relevant to industry as industry exists at the present time. These factors fall into two classes. On the one hand, there are various psychological facts which suggest that better results might be obtained if new methods of work were to be generally adopted. Individuals exhibit certain similarities in their mental and physical constitutions, as a result of which the adoption by all individuals of certain methods of work rather than of others would greatly increase the present industrial output, without involving any greater expenditure of individual energy. Put otherwise, the adoption of such methods universally would, so it seems, allow the present industrial output to be maintained with a less expenditure of individual energy than is involved in the use of present methods. On the other hand, there are many psychological facts which indicate that

some individuals are specially fitted by nature for certain kinds of labour and that other individuals are specially fitted for other kinds of labour. That is to say, certain psychological facts suggest to us that if, within limits, the operatives required for any kind of work were to be selected on the basis of natural fitness, the present industrial output could be maintained with a less expenditure of individual energy than is involved at present, or a greater output be obtained from the same expenditure of energy.

I shall begin by discussing certain psychological factors relevant to the construction of good methods of work. There are two facts here to which I wish to draw special attention. The *first* is that *fatigue* is a condition of the human organism which lowers the organism's efficiency: at least, there is no doubt that this is so when the fatigue becomes considerable. It would thus appear that if we could determine the factors which operate in the production of fatigue, we could utilise the consequent knowledge in the construction of relatively non-fatiguing working methods. The *second* fact is that the muscle groups are arranged and co-ordinated in the body in various definite ways. It would thus seem that good methods of muscular work should utilise as far as possible these natural arrangements and co-ordinations. I propose, then, to discuss these two facts, the second rather briefly, the first at some length. And, lest I should give a false impression, it is necessary to preface these

discussions with the statement that other important facts are also relevant to the construction of good methods of work.

§ 2

Fatigue

No study of fatigue that is adequate for industrial purposes has yet been made.[11] Nor, indeed, has there yet been published any adequate co-ordinated summary of such knowledge of the question as has been obtained. It thus results that, should anyone desire to eliminate or reduce industrial fatigue in any given case, it is almost impossible for him to obtain practical formulas from the literature on the subject.

A certain amount of relevant knowledge has been acquired by employers in recent times, as a result of various modifications made by them in their establishments, sometimes for humanitarian, sometimes for commercial purposes. It has been found, for instance, that, within limits, a shortening of the working day gives an increase in output, though this is partly dependent upon the nature of the occupation. This principle, for example, will hardly apply to a tram driver.

[11] Perhaps the most interesting (and popular) discussion of the question is to be found in A. Mosso's *Fatigue* (being the English translation by M. and W. B. Drummond, 1906, of that author's *La Fatica*).

And employers, as a whole, must have in their possession other valuable knowledge about industrial fatigue.

Further, psychologists and physiologists have carried out experiments to determine the nature and extent of the fatigue produced in this or that special set of conditions. Such knowledge as has thus been obtained, we are now beginning to collate and to utilise as the basis for generalisations. Recently, the British Association for the Advancement of Science, recognising the importance of the subject, appointed a committee to compile a fatigue bibliography, and this, when completed, contained over 1,700 items.[12] Commissions were also appointed some time ago by the British Minister for Munitions, for the purpose, primarily, of investigating fatigue in the case of munition makers. As a result of the investigations several very interesting reports have been published. Among these are *Industrial Fatigue and its Causes* (1916, Cd. 8213); *Second Interim Report on an Investigation of Industrial Fatigue by Physiological Methods* (1916, Cd. 8335); and *Industrial Efficiency and Fatigue* (1917, Cd. 8511).

The fact is that we are only now beginning to acquire *precise* knowledge about fatigue. Even if we know something of the causes and the effects of the industrial fatigue which occurs immediately as the result of any particular work,

[12] *Cf.* an article on "Industrial Fatigue" by C. K. Ogden (*Nineteenth Century*, Feb., 1917).

we know almost *nothing* of the cumulative effects of fatigue, which, nevertheless, in the large industrial centres of the world, are obvious to a careful observer, and seem to amount to a kind of general disease.

I propose, then, to consider the following questions: (*a*) the nature of fatigue; (*b*) some present industrial causes of fatigue; (*c*) the effects of fatigue upon industry; and (*d*) suggestions for lessening industrial fatigue.

(*a*) We may regard fatigue as a *mental* or as a *physiological* phenomenon.

Mentally, fatigue appears as the *feeling* of tiredness or weariness, with which everyone is more or less acquainted. This *feeling* has numerous degrees of intensity. It may range from simple boredom to the experience of sheer exhaustion. In its extreme forms it is always painful, and may cause continuous and intense suffering. According to one theory, this *mental* phenomenon is simply the *effect* of the physiological state of the organism when it is experienced; and, according to this theory, it is this state of the organism which should properly be called fatigue.

Physiologically, fatigue is the condition of temporary bodily "exhaustion" which occurs whenever the organism requires rest. So far as the material elements of the living body are concerned, life involves a continual change of structure. The living cells of which all anima

tissue is constructed continually assimilate inorganic materials. As well as seizing upon lifeless matter, the cell throws off the matter that has been used up. Chemical wastes thus expelled are simply poisons, and, if they accumulate in the blood, physiological fatigue ensues. It is possible that what we call "mental fatigue" is often due to this same cause. Bodily fatigue, then, and possibly mental fatigue, also, is a kind of poisoning. Temporarily the piling up of fatigue-toxins has outrun their removal. Normally, the body rids itself of these poisons as soon as they are formed; but if the blood be laden with them to the point of fatigue, rest is needed during which the blood may be purified and the poisons expelled from the body.

(*b*) There is no doubt that the fatigue caused by modern industry is of considerable proportions. To realise this, one has only to observe operatives returning from work, or even proceeding to work, in any large industrial centres of the Old World. Is it possible to state how this fatigue has been caused, to isolate those factors of industry which specially tend to produce it?

Among such factors I may mention, *first*, the long working day, which has been reduced to its present length, as is well known, only against great opposition. It is, of course, obvious that the mere length of the period of work may produce much fatigue. Although it was not a

recognition of this fact which induced legislators to shorten the daily period of labour, the principle of a reasonable working day is now generally accepted. Even yet, however, there is no precise and complete agreement as to what constitutes a "reasonable" working day; and the old long hours are still often introduced in the form of *overtime*. From the point of view of an ideally organised industrial community, overtime is bad, and the tendency is to eliminate it whenever possible. During the hours that follow upon the work of a normal day, the worker is in a tired condition, and further work, if continued for any length of time, may be seriously detrimental to his health: not to mention that, as will be shewn later, the quantity and quality of his work when he is fatigued are both relatively poor, and that he is then more liable to accidents.

A *second* factor in present day industry especially productive of fatigue is the speed of modern machinery. It would appear that there is a certain natural rhythm and rate of working for every person, and, when machinery is not accommodated to these, fatigue in all probability is rapidly produced. Until recently scarcely any attempt has been made to construct machinery that shall be adapted to the human element which is to operate it. The feature of great speed in modern industry, speed to which the workman simply must adapt himself in the present circumstances, is illustrated in such occupations as that of the operator in the

telephone exchange, or that of the girl who is in charge of one of the recent sewing machines which carry twelve needles and sew 4,000 stitches per minute, each needle having to be watched for breaking thread and adjusted to its proper place in the material sewn.

A *third* factor of considerable importance is *noise*. Near to deafening noises, or to noises which, if not deafening, are frequently of a grinding and scraping nature and altogether unpleasant, the industrial worker must often spend the greater part of each day.[13] Practically no efforts have as yet been made to decrease noise for the benefit of the workers, nor even for the sake of the output, which would almost certainly be beneficially affected by such a decrease. Nor, indeed, has there been much attempt to construct workrooms, in which noise is not directly produced, in secluded and quiet places. It is probably very bad in every way for men to have to do *mental* work in the midst of noise. They may sometimes think they are not affected by it, though this would probably

[13] *Cf.* Josephine Goldmark's *Fatigue and Efficiency* (pp. 68-71). Miss Goldmark says: "Noise not only distracts attention but necessitates a greater exertion of intensity or conscious application, thereby hastening the onset of fatigue of the attention. A quite uncounted strain upon this easily fatigued faculty results among industrial workers, such as girl machine operators, when the deafening intermittent roar of highly speeded machinery adds its quota to the tax of a long day's work. The roar is not even continuous enough to sink into monotony. With each stoppage and starting of a machine, it bursts out irregularly." (p. 71).

not be often, but records shew that they are.[14] It is, of course, not easy to prove that noise produces fatigue ; but it is easy to prove that it decreases efficiency. This, indeed, is a matter of common observation, and confirmation of the fact is not wanting in industrial records. For instance, it has been found that, simply by removing workmen from a yard in which trucks were being constantly pushed about, to a quiet place, their output was increased 25 per cent. It therefore seems obvious that every precaution should be taken to decrease noise in modern industry ; and that no one should be made to work near noises unless it is absolutely essential. Instances in which workrooms seem to have been arranged on precisely the opposite principle are not far to seek. And to have schools, for example, in such positions that teachers and children often cannot hear each other speak, is both wasteful and cruel.

Fourthly, I must refer to perhaps the chief tendency of modern industry, that, namely, towards more and more specialisation. This tendency results practically in the necessity for any one workman repeating many times in each day precisely the same movements of finger, hand, and body, and the same efforts of sense-

[14] The influence of *noise* upon " reaction-time ' is of special significance here. *Cf.* below (pp. 112-115) and the experiments of Wundt, an account of which is given by W. James (*Principles of Psychology*, pp. 427-432) ; quoted also by Josephine Goldmark (*Fatigue and Efficiency*, p. 70).

attention and will. Writers have often referred to such conditions as "monotonous"; but "monotonous" is a loose word, and may include a reference to features that are, at any rate, not uninteresting.[15] What is to be emphasised is that the specialisation tendency involves the frequent exercise of *the same parts* of the body and of *the same elements* of the mind. It scarcely needs to be pointed out that, unless precautions are taken, this procedure will lead to the over-fatigue of *the processes involved* in any industrial operation, though perhaps not directly to *general* organic fatigue. There is no doubt that the tendency towards specialisation rather lessens the chances for the occurrence of *general* exhaustion as a direct effect of labour. The question thus is whether it is possible to devise methods which will prevent the over-fatigue of the special processes of the mind and parts of the body involved in any sort of work. I shall shew presently that this does seem possible.

(*c*) I proceed, now, to discuss certain industrial effects of fatigue. I shall omit from this discussion all reference to the results of fatigue upon the general health and social activities of workers, although this is a highly interesting and important question. Two questions only will be considered. These are: (1) the influence of fatigue upon industrial accidents; and (2) the

[15] *Cf.* the article by C. K. Ogden on "Industrial Fatigue" (*Nineteenth Century*, Feb., 1917; pp. 423-424). See also F. B. and L. M. Gilbreth (*Applied Motion Study*, pp. 174-182).

influence of fatigue upon the quantity and quality of output.

These two questions are of interest to both employer and employee. The employee clearly does not want to be the subject of an accident, while, with a Workers' Compensation Act, the employer must desire to obtain the greatest possible decrease in the number of accidents. Again, the employer is interested in quality and quantity of output, and so is the employee ; at least, wherever piece rates are in operation, the employee desires as large an output as possible.

While emphasising, as I proceed, what may be termed the utilitarian aspect of the fatigue question, I would not be taken to mean that this is the only aspect from which we may judge that it is desirable to eliminate all unnecessary industrial fatigue. There is another, and, to some persons, a more important aspect of the question from which this end appears at least equally desirable. This is that the elimination of industrial fatigue will render possible for the industrial worker a mental and bodily condition which, though not constitutive of, is nevertheless a prerequisite for, an ideal social life.

(1) In 1884 Germany adopted a comprehensive system of national accident compensation, and investigations were undertaken in 1887 to determine the hours of the working day during which

the greatest number of accidents occurred. It was found that in the first few hours of the morning, when the workers were refreshed by the night's rest, there were relatively few accidents, and that the number per hour gradually increased, the maximum occurring between 10 and 12 a.m. During and immediately after the lunch hours the number of accidents was much smaller; but as the afternoon wore on the numbers increased, the greatest number occurring between the hours of 4 and 6. That is to say, the maximum of accidents in both the morning and afternoon coincided, generally speaking, with the period during which the labourers were probably most fatigued. These earliest results have been confirmed by later statistics in Germany and also in America, England, France, Belgium and Italy.

I shall give here several tables shewing the number of accidents occurring during the various working hours in different countries and years.[16] The number in the percentage column for any hour (in any Table) is the percentage which the number of accidents in that hour is of the total number of accidents (in that Table).

[16] A considerable amount of interesting statistical matter concerning industrial accidents will be found in the Bulletin of the U. S. Bureau of Labour Statistics, entitled "Industrial Accident Statistics" (No. 157 ; 1915). On p. 62 of this publication, there is a table shewing the distribution, among the *twenty-four* hours of the day (numbers and per cents. are given) of the industrial accidents occurring in Illinois in the years 1910, 1911, and 1912.

Table I.

Accidents in Germany

in all industries, during the year 1887. The *Table* shews the distribution of the accidents among working hours.

Hour of Day.	No. of Accidents.	Percentage of Accidents.
Morning.		
6 to 7	435	3·51
7 to 8	794	6·41
8 to 9	815	6·57
9 to 10	1,069	8·63
10 to 11	1,598	12·88
11 to 12	1,590	12·82
Afternoon.		
12 to 1	587	4·73
1 to 2	745	6·00
2 to 3	1,037	8·36
3 to 4	1,243	10·01
4 to 5	1,178	9·50
5 to 6	1,306	10·53

Table II.

Accidents in Illinois, U.S.A.

during the year 1910. These statistics were collected by the Illinois State Department of Factory Inspection. The *Table* shews the distribution of the accidents among working hours.

Hour of Day.	No. of Accidents.	Percentage of Accidents.
Morning.		
7 to 7.59	79	3·71
8 to 8.59	120	5·63
9 to 9.59	193	9·05
10 to 10.59	246	11·54
11 to 11.59	257	12·05
12 to 12.59	49	2·30
Afternoon.		
1 to 1.59	111	5·21
2 to 2.59	156	7·32
3 to 3.59	227	10·65
4 to 4.59	260	12·20
5 to 5.59	145	6·80
Other hours	289	13·56

Table III.

Accidents in Lancashire, England,

in the Cotton Industry. These statistics were presented to the Departmental Commission on Accidents in 1908. The *Table* shews the distribution of the accidents among working hours.

Hour of Day.	No. of Accidents.	Percentage of Accidents.
Morning.		
6 to 7	240	4·33
7 to 8	457	8·24
8.30 to 9	316	5·69
9 to 10	372	6·71
10 to 11	665	11·99
11 to 12	623	11·24
12 to 12.30	651	11·74
Afternoon.		
1.30 to 2	222	4·00
2 to 3	335	6·04
3 to 4	536	9·67
4 to 5	512	9·24
5 to 5.30	615	11·09

Table IV.

Accidents in Illinois, U.S.A.,

in the Manchester Industry, during the years 1911, 1912 and 1913. The *Table* shews the distribution of the accidents among working hours.

Hour of Day. Morning.	No. of Accidents.	Percentage of Accidents.
7 to 7.59	695	6·49
8 to 8.59	970	9·06
9 to 9.59	1,275	11·90
10 to 10.59	1,485	13·86
11 to 11.59	1,438	13·43
Afternoon.		
1 to 1.59	886	8·27
2 to 2.59	1,253	11·70
3 to 3.59	1,382	12·90
4 to 4.59	1,327	12·39

It will be noticed that, in all four tables, which, it must be remembered, are typical of others, there is a general tendency for the number of accidents to increase in succeeding hours both in the morning and afternoon. In order to bring out clearly the great similarity between these tables, so far as the relationship between the two factors compared is concerned, the curves representing them are shewn in the following figures.

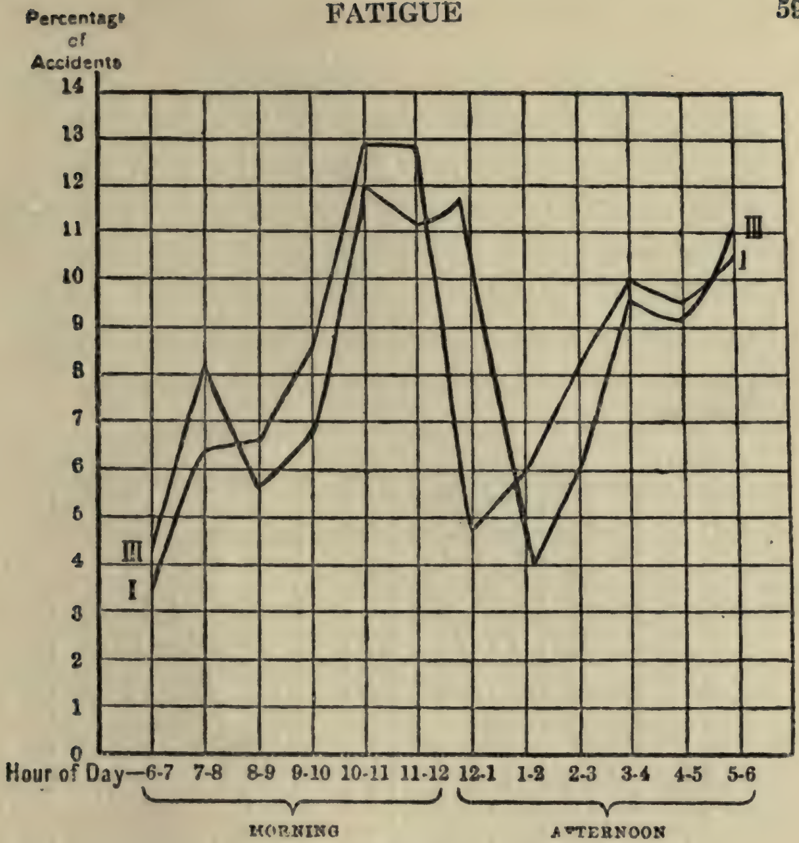

FIG. I.

Distribution of industrial accidents among working hours, as shewn in TABLES I. and III. (I. refers to Germany—*all* industries—in 1887; III. to Lancashire, England,—Cotton Industry only,—in 1908).

Considering the differences of locality from which, and the times when, the statistics represented by these two curves were collected, the similarity between them is very striking. It will be seen that the curves dip slightly towards the final hours in both morning and afternoon. The explanation of these dips is almost certainly that, so far as the morning is concerned, there were, during the hours represented by the

dips, relatively few operatives actually at work, owing to the intervention of the lunch hour; while in the afternoon a short interval for refreshment in many establishments probably allowed for some recovery from the effects of fatigue, and thus temporarily decreased the rate of the occurrence of accidents. Similar features are noticeable in the two following curves also,

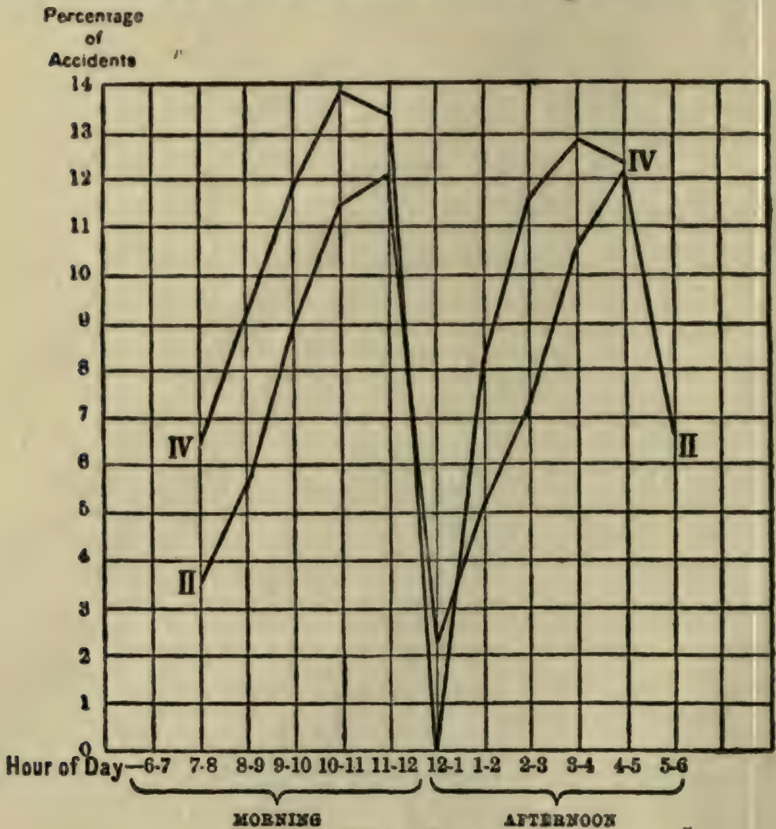

FIG. II.

Distribution of industrial accidents among working hours, as shewn in TABLES II. and IV. (II. refers to Illinois, U.S.A., in 1910; IV. to Illinois also, but in 1911, 1912, and 1913).

though the big drop during the last hour of the day in the curve of Table II. is probably due to the fact that many operatives ceased work before, or in the early part of, that hour.

Altogether, the similarities with regard to the general character of all four curves are considerable, and seem to indicate that fatigue has an important bearing upon the occurrence of accidents. Such a conclusion should, however, be accepted with caution, and neither the tables nor the curves should be treated uncritically. This is seen from the following consideration.

All statistics of accidents published so far, including those given above, provide no information on one important point: they do not tell us the numbers of men actually at work during the different hours of the day. If, for instance, from nine to ten o'clock in the morning twice as many men were at work as from eight to nine, it would not be surprising, nor significant, if there should be twice as many accidents during the later hour as during the earlier. The assumption made by those who have collected accident statistics and arranged tables seems to have been that, with the exception of the lunch period, as many persons were at work at any one hour of the day as at any other. A little reflection shews that this is by no means obvious. It may have been so in particular establishments; but, taking the industrial centres with reference to which the tables were constructed as *wholes*, it almost certainly was not. It is likely, on the contrary,

that during the first hour recorded on any of the above tables, fewer persons were at work than during the second, for the simple reason that some kinds of occupation begin later in the day than others: "counter-jumping," for instance, begins later than milk-carting or tram-driving, and in some establishments a relatively small number of employees begin work somewhat earlier than the majority by "getting things ready" generally. To some extent, therefore, the first obvious generalisation from the above tables must be qualified.

But we have no reason to expect that, with regard to *certain* hours, more persons were at work during one than during another. Thus, we have no reason to suppose that more persons were working between ten and eleven in the morning than between nine and ten, or, similarly, that more were working between three and four in the afternoon than between two and three. Consequently, if, when we compare the numbers of accidents occurring during these pairs of hours, we find that in each case the number is larger in the later hour, we shall have a result that can probably be relied upon for the purposes of arriving at a tendency. And the tendency thus brought to light is clear, as the tables show: that is, *there are more accidents during the later hour in each case.*

It seems reasonable to suppose that the factor operative in producing this increase in accidents in the later hours is *fatigue.* We know, at any

rate, that the fatigue would be greater during the later than during the earlier hours. If, further, we consider in detail the immediate occasions of accidents, and the kind of situations in which they occur, it seems highly likely that fatigue would increase the number of them.

For instance, an analysis of the accidents in Illinois in 1910 shewed that only 17 per cent. were beyond "the control of the victims," in the ordinary sense of this phrase. The analysis of the causes of accidents presented by the Departmental Committee in 1911 shews that in 90 per cent. of the cases fatigue *may* have been the cause, while in only 7 per cent. is it definitely excluded. This analysis covered 1,143 accidents in cotton factories, these accidents falling under the following heads :—

Table V.[17]

Knocking against machine	154
Kicking spinning carriage slip	134
Falling or making false step	200
Caught, e.g., trapped between rollers	238
Cut by tool in use, etc.	139
Fainting	5
Breaking (of strap, etc.)	6
Cut or hit by falling object	59
Splinters	97
Scalded or burnt	19
Sprains, strains, blisters	69
Climbing on headstock	23
Total	1,143

[17] Quoted from C. K. Ogden's article on "Industrial Fatigue" (*Nineteenth Century*, Feb. 1917).

If we analyse the accident situation still further, it seems probable that many industrial accidents occur as the result of a fatigue of certain *mental* processes. Some, of course, are due to faulty machinery, or to animals, or even to weather conditions; but these seem to be in a minority. The psychological facts here relevant are these: accidents frequently occur because a person does not make *the correct motor response* (or movement) in a given situation; correct motor response to a situation is dependent upon an *accurate perception of the situation*, and *a memory of the correct response* in such a situation; *fatigue* interferes both with *accurate perception* and with *memory;* in an accident situation, therefore, fatigue will operate to interfere with appropriate response, and, if the correct response be made, to delay more or less the making of it; a small delay in responding with the correct movement may mean that an accident happens, especially where modern machinery is concerned.

The same result is obtained if we consider the influence of fatigue upon *attention*. Much machinery makes a constant demand upon this mental process. Now the capacity of attention is weakened by fatigue. It is common knowledge, indeed, that fatigue makes the attempt to attend difficult. It hardly needs to be said, therefore, that a slackening of the *attention* of operatives may readily result in accidents.

The way in which accidents result from the

inevitable failure of attention and motor control in long spells of work is suggested strongly by any description of accidents not directly due to faulty machinery or animals. Here are a few taken from actual records: "Did not get her hand away soon enough and thumb was caught between billets." "Placed his finger too close to cutter in putting in the piece of work." "In some manner he got small finger of right hand against the saw while the same was in action." "Did not get his hand out of the way in time, and his fingers were caught between plunger and socket." "His hand slipped over the guard and was caught in the knife." "Hand slipped on to the rip saw." "Her finger slipped into the gear of the machine."[18] And so on.

I conclude, then, that fatigue is a prime factor in the cause of industrial accidents. If this be so, the ordinary conception of an accident should be modified somewhat; for an "accident" caused by fatigue is no more accidental than a case of typhoid fever caused by drinking bad water.

(2) The question to be discussed now is the influence of fatigue upon the quantity and quality of output. The argument here is similar to that used in treating the analogous question of the influence of fatigue upon accidents. That is to say, I shall present certain typical sets of figures which seem to shew that, in the later hours

[18] Quoted from C. K. Ogden (see preceding note).

of the day, when, presumably, fatigue is relatively greatest, quantity and quality of output are both relatively poor.

I shall begin by quoting the opinion of Mr. Frank B. Gilbreth, a well-known American efficiency expert. Mr. Gilbreth[19] attacks the fatigue problem primarily with the purpose of increasing the dividend of capital; and so convinced is he that fatigue *is detrimental to output* that he lays it down as a fundamental principle in the management of industrial establishments, that, wherever fatigue is found, measures should be taken to eliminate it, whether the employer can see that beneficial results will follow or not. The opinion of an "efficiency expert" of wide experience upon such a question is clearly valuable; but we are not dependent upon opinion.

In proceeding to statistics to shew the influence of fatigue upon output, I shall begin by quoting a colonial case. A Tasmanian gentleman who is a large apple grower, and who employs 75 families permanently on his estate, has long been interested in attempts to improve conditions of work, and has, indeed, been able to introduce a number of interesting improvements in the primary industry in which he is engaged. Here I shall refer only to certain of his experiences relevant to the fatigue question. He has a staff of six or eight apple packers who, on piece work,

[19] See *Fatigue Study* (F. B. and L. M. Gilbreth, 1916).

earn from six to eight shillings in an eight-hour day. On a neighbouring estate is a brother with a similar packing staff. On one occasion a large order came to hand and had to be got ready quickly. His brother's staff of packers therefore asked to be allowed to work ten hours a day, in order to cope with the order. His own staff kept to the eight-hour day, and at the end of a week,—the other conditions being similar,—the eight-hour packers had individually averaged between five and six cases of apples per day more than the members of the ten-hour staff. On another occasion, another neighbour asked this gentleman's staff of packers to work overtime for him, the rate offered for this overtime work being 50 per cent. more than the normal day rate. After three or four days the packers gave it up, saying it did not pay, as when they worked overtime they were unable to earn their usual normal day's wages.

Let us look at a manufacturing instance. "Some years since a large firm with shops both in Lancashire and in Belgium found that on identical work the output per man was greater in Manchester with its 51 hours' week than in their Belgian factory, where the week ran to 66 hours; and German shipbuilders have admitted that in their yards, in spite of the long hours worked, less is done per man per day than on the Clyde. Of course in these cases the comparison involves the working of men of different nationalities and this may affect the

results independently of the periods of work."[20]

Consider certain cases in which a difference of nationality is not involved. Some of the earliest attempts to record, at all precisely, the output at the several hours of the working day, were made in Italy. Professor Pieraccini, of Florence, collected details about the output of workmen engaged in several different sorts of manual labour. An accurate account of his investigation was published in the Proceedings of The First International Congress on Industrial Diseases (1906). I will give here two tables shewing the information obtained by him with regard to two sets of typesetters.

[20] Quoted from *Engineering* (Oct. 6, 1916; p. 331).

Table VI.

Output of six typesetters, members of the Typographical Co-operative Society of Florence, experienced men, working seven hours per day.

Hour of Day.	Average No. of Lines set.	Average in per cent.
Morning.		
8 to 9	20·2	13·62
9 to 10	25·3	17·06
10 to 11	21·6	14·56
11 to 12	20·8	14·02
12 to 2	Rest and lunch (2 hours).	
Afternoon.		
2 to 3	23·6	15·91
3 to 4	20·8	14·02
4 to 5	16	10·78

Table VII.

Output of four typesetters of the Niccolai Printing House at Florence ; also the distribution of errors among the different hours of the working day.

Hour of Day.	Average No. of Lines set.	Average in per cent.	Average No. of Errors.
Morning.			
8 to 9	21	13·75	17
9 to 10	26	17·02	10
10 to 11	23	15·06	18·28
11 to 12	21.5	14·08	28
12 to 2	Rest and lunch (2 hours).		
Afternoon.			
2 to 3	24·7	16·17	5·5
3 to 4	20·5	13·42	22·6
4 to 5	16	10·47	30

Graphical representations of these tables are given below (Fig. III.). It will be seen that the curves for the two tables are almost identical in both morning and afternoon hours. It will be seen, also, that the number of errors, in Table VII., increases rapidly at the same time as there is a decrease in the output, this being most conspicuous in the afternoon hours.

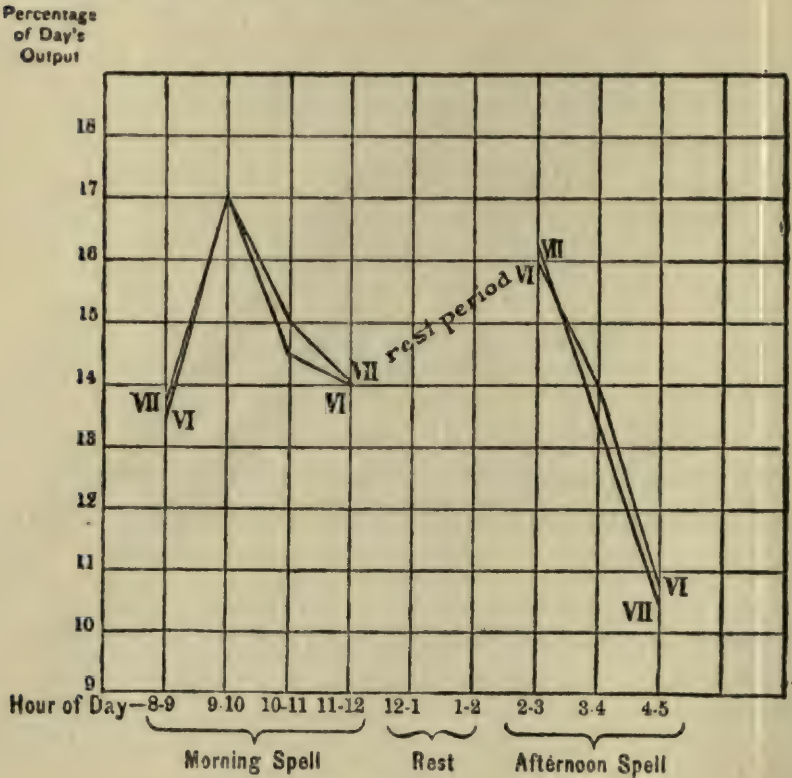

FIG. III.

Distribution of Italian typesetters' output among working hours, as shewn in TABLES VI. and VII.

I shall give a more recent record of an average typesetting output, which is to be found in the

1916 Report of the British Association Committee on "The Question of Fatigue from the Economic Standpoint." The figures there given shew that quantity of output decreased during the later working hours of both the morning and afternoon. In the case investigated, work began at 8 in the morning. From 8 to 9 the average number of "ens" set was 1,356, from 9 to 10 it was 1,383; 10 to 11 shewed a decrease in output, while from 11 to 12 the number of "ens" set was only 1,256. After the midday rest there was a considerable increase in the output, though not at once. During the first hour's work 1,248 "ens" were set, during the second hour 1,346, during the third, 1,394; but for the final hour there were only 1,188 "ens" to shew.[21]

It will be observed that, in this case, the greatest output in the morning was during the second hour: in the afternoon, during the third. This comparatively large output for the third afternoon hour is noteworthy. It is in striking contrast with the Italian figures, according to which the largest afternoon output was during the first hour. The explanation of the English figures, it has been suggested, is that the compositors were allowed a ten-minute interval for tea at the end of the second hour's work. Where no such interval was given, the evidence seemed to shew that the greatest afternoon output was in the second hour,—as the greatest morning

[21] *Cf. Engineering* (Oct. 6, 1916; p. 331).

output was in the second morning hour. On the other hand, the relatively large output of the Italians in the first afternoon hour was probably due to their long midday rest.

The three sets of figures agree in putting the largest morning output in the second hour. This result is in accord with the general conclusions of numerous investigations upon various kinds of work. The relatively small output in the first hour of the day is due to the fact that, for at least *a part* of that period, the workman is not properly " warmed up " to his job. Everyone is acquainted with this process of " warming up." In technical psychological language it is termed *incitement.*

It may now be asked what is the *practical* conclusion from such statistics as have been presented. Do you suggest, I may be asked, that work should cease immediately after the second hour in the morning, and again after the second hour in the afternoon ? After all, it may be said, while the English figures that have been quoted shew, for instance, a comparatively small output for the last hour in the working day, nevertheless, there will probably be a larger total output *in any considerable period* if this eighth hour is included than if the working day is reduced, say, to seven hours.[22] But that reduc-

[22] Mr. Harrington Emerson considers it misleading to say that shortening hours ever increases output. This position he bases partly upon sporting records which shew that, whatever the animal making the record, *not so much can be done in any given time as in any longer time,* provided that the best method is

tion of the number of working hours does not necessarily involve a reduction of output, seems to follow from a striking case published in the *Second Interim Report on an Investigation of Industrial Fatigue by Physiological Methods* (already referred to, p. 46).

In this report Professor A. F. Stanley Kent details the results of certain observations made at a factory where surgical dressings were manufactured. "Amongst those engaged here were a number of female yarn winders. Yarn winding is an operation requiring considerable dexterity and constant attention in the piecing up of broken threads. The schedule working hours ran from 6 to 8 a.m., from 8.30 to 12 30, from 1.30 to 5.30, and overtime was worked from 6 to 8 in the evening. One operative, a single woman of 32, persistently refused to work either before breakfast or after 5.30, declaring that the additional rest she thereby secured enabled her

always used. This best method would not be the same for any two periods differing in length. He then explains those published statistics which shew a larger output with shortening of hours by two facts : (1) under the old type of management an industrial concern was operated at about 35 per cent. of its maximum efficiency, which made improvement easily possible ; (2) when hours were shortened *methods of work* were modified, and these new methods resulted in realising some of the previously unrealised efficiency (see 1). Other factors were made to vary simultaneously with the length of the working day and consequently any alteration in output could not be assigned without very careful investigation to the mere shortening of the day. Output would have been increased, or certainly *could* have been increased, had the new working methods been introduced and the working day *not* shortened. There is clearly a sense in which this position is accurate.

to turn out more than if she worked the whole 12 hours. This claim was accordingly investigated, and her output during a month compared with that of three other first-class hands, who during the first fortnight of this month worked 12 hours a day, and during the remainder 10 hours a day. The 'slacker' won hands down. In addition to taking off quarters, as mentioned, she also stayed away the whole of one working day and three half-days, yet her output for the period under review was 52,429 bobbins, as against an average of 48,529 for the three first-class workers who worked full time. The best of her three competitors had an output of 51,641 bobbins, for which she worked about 237 hours as against the 160 hours worked by the short-timer." [23]

Such facts as have been discussed seem to justify us in holding two fairly general propositions; *firstly*, that a decrease in industrial fatigue will effect a decrease in the proportion of industrial accidents; *secondly*, that a decrease in industrial fatigue will effect an increase in the value of the industrial product. There is further justification for believing these propositions in the fact that the statistics that have been presented are more or less typical. Our practical

[23] Quoted from *Engineering* (Oct. 6, 1916; pp. 331-332). *Cf.*, however, the criticism of Professor Kent's conclusions in Publication No. 2 of The National Industrial Conference Board, Boston, Mass. The publication is called "Analysis of British Wartime Reports on Hours of Work as related to Output and Fatigue" (1917). See especially pp. 39-47.

conclusion, therefore, is that, from a purely utilitarian point of view, every effort should be made to decrease industrial fatigue.

(*d*) From the point of view of these lectures the question now to be considered is this: Is it known that this or that psychological condition produces fatigue, and, if so, can industrial methods be modified through the application of this knowledge so that industrial fatigue may be decreased? I do not propose to attempt any exhaustive answer to this question. I intend, rather, to discuss one particular psychological factor which is of supreme importance here, though this discussion will have a more general bearing. The psychological factor to which I refer is *attention.*

Everyone knows the sort of mental process that is called *attending* to something, and, indeed, there is a considerable amount of general and useful knowledge about it. It is known, for instance, by everyone, that it is often very difficult to concentrate one's attention upon a desired point. There is, also, some common knowledge of the causes of this difficulty. It would be generally agreed, for example, that it is more difficult to attend to anything when one is tired than when one is feeling vigorous, and that competition of "interests" interferes with the concentration of attention. It would also be commonly held that the mere process of concentrating the attention, even when there are no

distractions, is very exhausting. Confining ourselves to this last point, as being more relevant to our present purpose than the former ones, it is to be noted that science confirms the popular view. Psychology confirms the judgment that a strain upon the attention is extraordinarily exhausting. This fact is one of utmost importance here, for there is, in all probability, no other mental factor upon which industry makes so great and constant a demand as it does upon *the attention.* Industry, of course, often makes great demands upon the special sense organs and the adjusting apparatus connected with them; but the more constant demand upon *attention* can be seen from the fact that this process is involved, generally, *whatever* be the special sense organ used in a given case. And it needs but a small acquaintance with modern machinery to realise that a very great strain is often put upon the attention process by its employment.

We thus seem justified in believing that, could we lessen the demand made by industrial processes upon attention, or at least modify that demand in accord with the laws of recovery from attention strain, we should decrease industrial fatigue and also its bad consequences. I shall therefore discuss two methods, each of a very general nature, by which the attention strain and effort involved in present-day industry may be greatly relieved.

Firstly, mechanical arrangements may sometimes be introduced which altogether remove

the necessity for attending to particular processes previously involving attention. This may occur where frequent *acts of decision*, themselves of a fatiguing character, are required of operatives. If, for instance, a workman is required to make a definite act of decision every few seconds, the result will probably be a rapid production of fatigue; for, on the one hand, the process of deciding will be more or less fatiguing in itself, and, on the other hand, the attention involved in making the decisions *correctly* will cause an additional strain. Let us suppose that in some piece of machinery a wheel has to be moved forward a small distance every few seconds, the time between the movements varying with some other process, to which the operative must also attend. The man would, at a certain point, push the wheel forward a little, then bring it to a stop, watch for the moment when the push forward must again be made, make the required movement, again bring the wheel to a stop, and so on. Here there would be a constant demand on the *attention*, and a necessity for a continuous succession of small pushes and stoppings involving decisions. Such work would probably be comparatively fatiguing. Now, if, instead of a number of separate pushings and stoppings, the process were so arranged that the man could make one continuous rhythmical movement, in which there were no stops, the result would probably be much less fatiguing (provided there were appropriate pauses in the work). We may

say, in general, that our knowledge of the relation of attention and acts of decision to fatigue suggests that, wherever possible, continuous rhythmical movements should take the place of a succession of distinct movements. On the other hand, when the necessity for continuous attention cannot be removed, periods of work should be interspersed with appropriate pauses in accordance with certain knowledge which I shall discuss presently.

There is also another sort of case in which the industrial strain upon attention that involves the making of decisions may be modified so as to lessen this strain very greatly. I refer to those numerous kinds of labour,—which, indeed, seem to be growing ever more numerous,—in which a workman is required to perform a variety of operations in sequence, the order in which they are carried out depending, not upon machinery, but upon himself. In such cases the gain to be obtained merely from fixing the order of the operations must be very considerable. I may illustrate this principle by the following case, which, however, is very crude and imperfect, compared with another that I shall discuss in my fourth lecture.[24]

In a certain Sydney factory where piece rates were in operation, it was noticed that one workman used to make nearly 50 per cent. more wages than his fellows. It is, of course, well known

[24] See below, pp. 183-186.

that there are greedy workmen as well as greedy employers; and that these, by working intensely, sometimes make high wages when being paid by piece rate methods. It was found, however, that the workman in question certainly did not exert himself more than his companions; in fact, he seemed to work at even a slower rate than they, and appeared also less fatigued. The explanation was this. The man used to spend the first half-hour of each day collecting and arranging the material he would require throughout it, and making a definite arrangement of his tools. Thus, during his work, he knew precisely where anything was when he had need of it. He knew, for instance, just where to lay his hand on any particular tool; for, after he had used a tool, he would put it back in its own place. Thus, this man had found out that by a little arrangement he could work more easily and with *less worry*, and that he could turn out nearly 50 per cent. more than his comrades. It is to be noted that his method involved the elimination of those concentrated acts of attention which were necessary when, without a definite arrangement of material and tools, he wanted one or another of them, and the elimination of the decisions as to where tools were to be placed when not in use.

Secondly, the attention involved in much industrial work, such, for instance, as that of the telephone operator, seems almost inevitable. Where this is the case, it is necessary to proceed by a different method, namely, to endeavour to

introduce into periods of work appropriate pauses which will allow for recovery from the fatigue caused by attention strain. In discussing this question I shall emphasise the fact that the introduction of such pauses gives rise to increased output. I assume, that is to say, what seems fairly reasonable, that, just as a decrease in quantity or quality of output occurs when we are justified in supposing that there is an increase in fatigue, an increase in quantity or quality of output is evidence, generally speaking, of a decrease in fatigue. That is, it is assumed that fatigue and output vary inversely with one another.

It has long been known to employers that pauses are helpful in warding off fatigue. This rather obvious fact is, however, not of much value unless made precise. The question is how many pauses should be introduced in this or that particular work, and how long should pauses be in this or that particular work? These points can be determined only by an investigation in each case. It is fairly obvious, for instance, that the number and length of the pauses best suited to the efficiency of a wharf labourer, who must make numerous heavy lifts, in a day's work, would not be best suited to the efficiency of a typist. But I shall not enter here upon any discussion of practical maxims. What I propose to do is to discuss the experimental facts upon which the principle of pauses is based.

The Italian scientist Angelo Mosso invented

an instrument called the Ergograph by means of which it is possible to investigate the relation between work and fatigue in one relatively isolated muscle, or group of muscles. Mosso's Ergograph is shewn in Fig. IV. It will be observed that the arm is fastened down so that a relatively free movement with it is impossible. Further, the first and third fingers of the hand are inserted into small cases which hold them firmly and prevent them from moving. The middle finger, however, is allowed to move

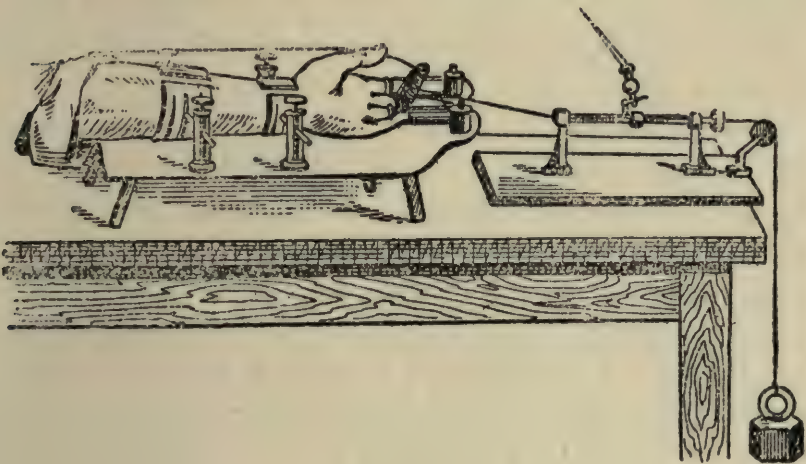

FIG. IV.
Mosso's Ergograph.

freely. It is placed in a sheath attached to a wire carrying a weight. This weight can be increased or decreased at pleasure. When a "contraction" is made with the middle finger, that is, when the finger is raised in the direction of the face of its owner, the weight at the end of

the wire is raised a definite amount. Now the raising of a weight through a certain interval of space is what is technically termed "doing work"; and it is easy to see that, if we make the middle finger perform repeated contractions until fatigued, we are able to calculate the amount of work the muscle of that finger is able to do. Since Mosso's invention of the Ergograph there have been various modifications and improvements of this instrument. Some of these aim at an investigation of muscles other than that of the middle finger of the hand. Other modifications are intended to make the task of calculating the precise amount of work done more easy. But the principle of all Ergographs is the same, and I shall therefore proceed to consider the character of the results obtained by these instruments. I shall limit the discussion to a consideration of experiments upon the middle finger muscle.

As would be expected, individuals shew considerable differences in their ability to lift weights with their middle fingers, some being able to lift much heavier weights than others. There is one point, however, in which all are similar. If no interval is allowed between the contractions, a condition is soon reached in which the finger is absolutely unable to move the weight at all. All power appears to leave the muscle suddenly, and, try how one will, not a single further contraction, or part of a contraction, is possible. Before a further contraction can be made, the finger muscle must be rested, the

length of pause depending upon various factors. What happens, in fact, is that the mechanism connected with the voluntary movement of the finger becomes completely fatigued, and a rest is required to allow the fatigue products to be carried off or burnt up.

The most interesting point is yet to come. It has been discovered that, if a sufficiently long pause is given between every two contractions of the finger, *no "fatigue" results* in a long period of work. For example, in a certain experiment with a load of six kilograms, no fatigue resulted, *that is, there was no definite stopping place*, in a long period of work, when a rest of ten seconds was given after each contraction. With a pause of only two seconds after each contraction, however, complete inability to contract the finger further resulted after about one minute, and no further contractions were then possible. Indeed, a rest of two hours was required before an equal quantity of work could again be done. Further still, although it might be thought that, if the work which required a two-hours' pause before the finger muscle could repeat it were to be lessened by one half, the rest required by the muscle for recovery from fatigue effects could be lessened by one half also, it is found, in fact, *that this rest can be lessened by much more than one half*. With a certain given weight, the muscle of the finger was so exhausted after thirty contractions,—occupying one minute,—that it required two hours to recover. After

fifteen contractions with the same weight,—occupying half a minute,—the finger required not one hour's rest, but only half-an-hour's rest: that is, after half-an-hour's rest it could repeat the fifteen contractions, and after another half-hour's rest repeat them again, and so on. This point may be put in general terms thus: if a certain amount of work requires a certain amount of rest in order to recover from the effects of fatigue, twice that amount of work requires *more than twice* that amount of rest, and, for instance, four times that amount of work requires *much* more than four times that amount of rest,—perhaps twelve times the original amount.

Let us consider the influence of this fact upon output, taking, as a hypothetical case, a day's work in lifting weights with the middle finger. Let us enquire what difference there would be as regards output between the two methods, *viz.*, 30 contractions and a pause, and 15 contractions and a pause. Let the weight be constant and such that the 30 contractions in one minute exhaust the muscle so that it requires a two-hours' rest. The two methods are then as follows: the first, 30 contractions, 2 hours' rest; 30 contractions, 2 hours' rest; 30 contractions, 2 hours' rest; 30 contractions 2 hours' rest (the odd minutes over the eight hours may be neglected). That is, four periods of work followed by four periods of rest exhaust the 8-hours' day. The total number of contractions

made during the day is 4 times 30, that is, 120. The second method is: 15 contractions, half-an-hour's rest; 15 contractions, half-an-hour's rest; and so on throughout the day. Now, an 8-hours' day is divisible into *sixteen* half-hour periods. The work in each case continues for one half-minute. Therefore, by this method, there would be 16 periods of work of half-a-minute each, followed, in each case, by a period of one half-hour's rest, neglecting the odd additional minutes as in the first case. The number of contractions of the finger made during the day by this method is therefore 16 times 15, that is, 240: that is to say, it is *just twice* as many as by the former method. Assuming that the amount of work accomplished by any contraction of the finger is equal to that accomplished by any other, that is, that it is a constant quantity, by the second of the two methods just twice as much *work* (output) is effected as by the former. This difference is due solely to an arrangement of pauses which allow for the fatigue poisons, relatively speaking, to be destroyed as they are produced.

Let us now put an extreme case. It was found, as I said, that if 10 seconds were allowed for rest after each contraction of the finger (with a certain weight), the work could be continued for a very long period. Suppose, then, that this method is used in a day's work. There would then be one contraction, occupying 2 seconds, and 10 seconds' rest; another contraction,

occupying 2 seconds, and another 10 seconds' rest; and so on throughout the day. Any one period of work and rest combined would thus occupy 12 seconds. Now, in an 8-hours' day, 12 seconds occurs 2,400 times. Therefore, by this method, there would be 2,400 contractions of the finger in a day's work; and this is *just ten* times as many as are made by the second method, and *just twenty* times the number made by the first method.

These points may be summarised briefly as follows. We are comparing the output of the middle finger when three different methods are adopted (the weight being constant). And we are using such a weight as will exhaust the finger in one minute by the first method.

The methods, then, are these:

(1) 30 contractions, each of which, together with the bringing of the finger back to position, occupies 2 seconds; and then two hours' rest.

(2) 15 contractions, each of which, together with the bringing of the finger back to position, occupies 2 seconds; and then half-an-hour's rest.

(3) 1 contraction, which, together with the bringing of the finger back to position, occupies 2 seconds; and then ten seconds' rest.

Then, in a working day of 8 hours, the output by

Method	(1) =	120	units.
,,	(2) =	240	,,
,,	(3) =	2,400	,,

This result must be qualified to some extent. Firstly, it is a *deduction* from certain experiments, and if the three methods were actually tried, as of course they could be, they probably would not yield *precisely* the figures given. Nevertheless, those figures, I think, give a *correct general impression* of the vast differences in output which may be effected by modifications of the number and length of pauses in a given period.

Secondly, we are probably not justified in supposing that the units of work are all equal. Some contractions are not so complete as others, which means that the output of work from these contractions is less than that from those more complete,—that is, the weight is raised higher by the latter. This fact, however, would almost certainly tell in favour of the second method as compared with the first, and in favour of the third as compared with the first two. For it is found that incomplete contractions occur most frequently toward the end of a fairly continuous stretch of work. If, after each contraction, time is allowed to recover from fatigue, there may occur no incomplete contractions. This fact means, among other things, that it is more

probable that any unit of work obtained by the first method or by the second is incomplete than that any unit of work obtained by the third method is incomplete.

I need hardly emphasise the importance of such facts as these. We do not know, with any precision, whether the Ergograph results for single muscles apply equally to the whole muscle system; but there seems no reason to suppose that they do not. Whether they do or not, the results obtained are obviously relevant to many industrial processes. In my fourth lecture I shall give cases in which the principle of the pause has been applied to industry with remarkable effects. These cases seem to indicate that the results obtained with the Ergograph from one muscle are, to a large extent, typical of what is true for the whole muscle system.[25]

§ 3

Muscle Co-ordination

I pass now to a very brief consideration of the *second* of the two facts referred to at the beginning of this lecture, namely, the arrange-

[25] For further details of Ergographic experiments, text-books on psychology should be consulted; *e.g.*, that by C. S. Myers. Some account of the early Italian work on the subject is given in Josephine Goldmark's *Fatigue and Efficiency* (pp. 18-20, and 33-34); see also A. Mosso's *Fatigue*. A useful analysis will be found in Dr. R. A. Spaeth's article, "The Problem of Fatigue," in *The Journal of Industrial Hygiene* (I., 1, pp. 24-26).

ment and co-ordination of the various muscle groups in the body (§ 1). I said that good methods of work should utilise these arrangements and co-ordinations. It is, of course, a commonplace that the whole development of modern machinery has tended toward the substitution of work done by small muscle groups for work done by the large muscles of the body. Instead of lifting heavy weights with the arms and body, a workman often now, though even yet by no means always,[26] moves with his hand a small lever which turns on power, and the weights are raised by machinery. This kind of development will probably continue, for its utility is obvious. The point I wish to indicate is perhaps not so obvious as this, and I shall therefore attempt to illustrate it by the following considerations.

When a muscle is voluntarily moved, there is involved the transmission to it of nervous impulses coming from the brain. This fact is popularly expressed by saying that we send an impulse, or a "message," to a muscle, or limb, when we will to move it. Now, the transmission of a nervous impulse to a muscle usually involves a certain amount of "overflow"; that is, impulses travel to muscles other than that to which they are meant to be specially directed, as well as to that muscle. These overflows seem

[26] For instance, men still carry hods of bricks up almost perpendicular ladders,—when they do not "pass" them to one another, one or two at a time.

to be more frequent in proportion as we are unpractised in the movement we attempt to make. A child learning to write will move his limbs, and body generally, in a way that is quite irrelevant to the particular movements at the performance of which he is aiming. It would seem that, when we wish to perform some novel movement, the central nervous system "innervates" the greater part of the whole muscle system. ("Innervation" is the technical term for the transmission of impulses to a muscle). This general muscle innervation seems to be gradually, with practice, more efficiently directed. It is then run into the particular channel leading to the muscle whose innervation is involved in the desired movement. The first large and almost directionless emission of impulses is gradually canalised. Even when we become practised in special movements, however, there does not seem to be any *total* canalisation of the impulses transmitted to particular muscles. The "canals" seem always to overflow somewhat, and often the overflows are considerable.

These overflows seem to happen in two ways which are industrially of significance. (1) Firstly there is normally some overflow of impulse to muscles situated in the vicinity of the specially innervated muscle. That is to say, the innervation of any one muscle, or group of muscles, normally involves *some* innervation of other muscles, or groups of muscles, situated near it. Consequently if, immediately after innervating

one particular muscle, we desire to innervate another near it, the innervation of the second muscle will not involve a transmission of so large an amount of nervous impulse as if the first muscle had not been innervated. The importance of this fact to industry may be illustrated by reference to methods of typewriting. It allows us to understand how the use of all the fingers in typing is not only a rapid method of operating, but also little, if any, more fatiguing than the "one finger" method; for by using one finger only, the overflow impulses to the neighbouring finger muscles,—involved in every innervation of the muscle of that one finger,—are simply wasted, whereas in the "all fingers" method they are utilised. It is possible that this fact alone is capable of an extensive application to industry.

(2) The second way in which overflow impulses happen is not so clear, but perhaps more interesting. It would seem that, when we innervate a muscle or muscle group on one side of the body, there is some innervation of the corresponding muscle or group of muscles on the other side of the body. There is some evidence of this overflow in the following rather curious phenomenon.

If you take a pencil in your left hand, and, closing your eyes, attempt to write freely with it, allowing the letters to slant, and also writing the words, from right to left, you will very probably have the feeling that what you are

doing is somewhat familiar, although you have never done it before. If you then hold what you have written before a mirror, you will probably see in the mirror the word or words you intended to write, though, of course, badly written. That is, you have written with your left hand in a *reverse* form what you have learned to write with your right hand. It is certain that you did not deliberately learn this reverse writing with your left hand: your learning it was quite unknown to you. What, then, was the process by which you acquired it? A very likely explanation seems to be that when, in learning to write, you innervated the muscles of the right hand and arm, you innervated also the similar muscles of the left hand and arm; and that this innervation, both then and after you had learned to write with the right hand, left behind it some physiological modification of the parts concerned, which made the reverse writing, when you tried it, possible, and in fact apparently easy.

If, then, we suppose that the innervation of muscles on one side of the body normally involves some innervation of the corresponding muscles on the other side of the body, we have an important fact for industry. The *application* is that, *in constructing good methods of work, we should, as much as possible, give scope for the simultaneous, or almost simultaneous, exercise of similar muscles and groups of muscles on the two sides of the body.* In this way, at least, we should

be making possible a utilisation of nervous impulses which, in any case, are emitted, and which are often wasted. It is not difficult to see that the application of this fact might also involve a great saving of time.

It seems highly probable that there are intimacies and associations between various muscle groups which give rise to many other instances of "overflow impulse" besides the two I have mentioned. It is the task of science to discover where such associations exist. The principle for the application of our knowledge of them, once they are known, is, however, perfectly clear, and need not be discussed further.[27]

§ 4

Individual Differences

I now proceed to consider some of those psychological facts which suggest that individuals differ in their natural fitness for certain types of work.

It is common knowledge that differences between people are often very great. We say, for instance, that it is no use disputing about tastes. One person likes tomatoes and olives and another does not, and, so far as tastes are

[27] Students will find many of the facts stated in Professor C. S. Sherrington's *Integrative Action of the Nervous System* highly illuminating in this connexion.

concerned, the matter is ended. Again, it is part of our ordinary knowledge that there are more precise kinds of differences between persons than in regard to taste. Everyone knows the boy who can be picked out from his comrades because of his turn for mechanics; who will mend a bicycle or a clock where another boy would be helpless. Such facts as these have formed the starting point of the *psychology of individual differences*.

As an instance of the kind of fact which this branch of experimental psychology has brought to light, I shall refer, first, to the capacity for repeating from memory ordinary numbers. If I write upon a blackboard two numerals, allow them to be seen for one second, and then ask to have them repeated, most people would be successful. Perhaps the same would be the case with three numerals. With four, some people would make mistakes, and with five the number making mistakes would be still larger. I might continue until, when I had reached, say, twenty numerals, no one could be found who was able to repeat them correctly. It has been discovered, however, that some persons have a remarkable aptitude for such a task, and several notable instances of this capacity have been chronicled. For example, one man, it was found, could repeat correctly 44 numerals after he had seen them about one second, and another almost as many. Such ability is probably very rare; but, where it does exist, there seems no reason why society

should not utilise it. Why should a man with such a capacity spend his life in an employment which does not bring it into use?

It may seem, however, that such ability is so rarely met with that the difference made by its application to industry would be, on the whole, very small. And it might be thought that the same would be true of other capacities. Concerning the special case before us, this consideration is probably justified; but in other cases the result would be different. I shall now, therefore, discuss certain differences which psychology has revealed between persons, which may have an important bearing upon economic results.

One of the most striking of these concerns the *rate of perception*. It has been found that certain persons are able to perceive with much greater rapidity, and, at the same time, with no less accuracy, than others. Differences of perception occur in connection with all the senses. Suppose, for example, that several people see the same cinematograph film, and afterwards describe as minutely as possible everything that they have seen. It will be found that all do not see as much as some, and, if the number of persons who see the film be considerable, say 50, it will be found that some see roughly twice as much as others. As a result of experiments with University graduates and undergraduates, men and women, in which the "subjects"[28] were

[28] "Subject" is the technical term for the person being experimented upon.

required to watch small moving pictures and afterwards to report what they had seen, I found that some were able to report *three* times as many items as others ; and it seemed clear, for various reasons, that this was due to a more rapid vision. Such a difference is interesting, seeing that all the "subjects" had had much the same intellectual training.

Again, most "picture goers" occasionally experience difficulty in reading, in the time given them, the explanations that are now and again put upon the screen. Let us suppose that there is thrown upon the screen a letter in which one man offers another £1,000 if he will disable a horse which is to run in a certain race. Suppose that there are 100 words in the letter, and that it is left upon the screen for ten seconds. Then, in order to read the whole of it, one would need to read at the average rate of 10 words per second. Some people *cannot* read so quickly ; their capacity for *visual* perception is not sufficiently good. Others, however, can easily read at this rate, and even at a much greater one ; and such persons would have the whole letter in their minds some seconds before "the pictures" began once more. It has been shewn experimentally that some people read *four times* as quickly as others.

The general point thus is that some persons can perceive by sight much more rapidly than others. The question which industrial psycho-

logy now asks is this: Are there any departments of industry where rapid visual perception is of great importance? And the answer is that there undoubtedly are industries in which quickness of visual perception is important, and, in fact, even now insisted upon to some extent. The driver of an electric tram, for example, needs a capacity for quick perception by sight. At present, railway and tramway men must pass an optical test; but this is designed chiefly to exclude such men as have poor sight or are colour-blind. Now a person may have *good* sight, in the sense that he can see well at a long or close range, while at the same time he may *not* have *rapid* sight. And what I am emphasising at present is this capacity for *rapid vision.* It is fairly obvious that differences in respect of this capacity could be utilised industrially, although just how would depend upon the character of any industry. (It may be remarked that the sight-tests already employed by railway departments represent an application of psychology to industry.)

It has been shewn, also, that different persons differ considerably in their capacity for touch perception, some being much quicker and more precise than others, just as certain parts of the one body are more sensitive to touch sensations than other parts.[29] A still more obvious field for individual differences is the hearing, and here

[29] Relatively high touch sensitivity would be important in such an occupation as that of wool-classing.

common observation suggests that individual differences must be considerable. The point then is that such sense differences could be utilised industrially; that is, if there are industries requiring certain capacities of sight, hearing, or touch, persons could be selected for such industries who have naturally the required capacities.

Consider, now, individual differences in the capacity for making precise movements, whether these be simple or elaborate,—what may be called broadly motor capacity. There is no need to emphasise the industrial significance of individual differences here, provided they exist; and they not only exist but are considerable. Some persons can readily learn a method involving the use of all the fingers in typing, while others find this difficult if not impossible and never reach the stage at which typing becomes pleasantly easy. The same is true of the playing of certain musical instruments, such as the piano. It is indeed common knowledge that some people are particularly deft with their fingers, while the fingers of others are all thumbs. If you get a dozen boys to throw darts at a target some will throw much more accurately than others, independently of differences in practice. Some persons easily acquire a back-hand stroke in tennis; others with great difficulty or not at all. Some persons can carry a glass full of water along a corridor in the dark without spilling any; others cannot. If you

arrange a number of circular holes in a metal plate, the diameters of which make a series of decreasing size, and require subjects to hold a thin metal rod inside these holes without touching their edges for fifteen seconds each, you will find that in respect of the *steadiness* demanded some persons have much greater capacity than others. If you arrange two lines two millimetres apart in varying pattern and require subjects to draw a pencil point between them without touching either, you will find that some persons can do this better than others. And if you construct a pendulum from a hollow metal rod, lead water through it, and require subjects to catch the water in suitably small receptacles such as brass test tubes, while the pendulum is swinging, you will find that some subjects carry out the necessary movements much more precisely than others.[30]

The term *motor capacity* is clearly complex. It is necessary to specialise capacity for movements in at least three directions. We may speak of (1) capacity for *precision* of movement, (2) capacity for *complexity* of movement, and (3) capacity for *strength* of movement. Laboratory tests may be devised to discriminate between persons in all three capacities. I shall mention simply *The Martin Strength Test* as a means for

[30] This apparatus is due to Dr. W. R. Miles (Nutrition Laboratory of The Carnegie Institution of Washington, Boston, Mass.), who calls it very appropriately, *The Pursuit Pendulum*.

bringing to light individual differences in the third of these.[31]

Still another factor of importance here is a person's attitude towards monotony and variety. This problem has not been investigated to any great extent. We know from our own experience that the feeling of monotony is disagreeable, and we may therefore infer that it has a bad effect upon efficiency. Similarly, variety is often pleasing, and so far may be said to be advantageous to efficiency. It seems likely, however, that persons may be divided into two classes according to their attitude to monotony and variety. There seem to be some who welcome work which would ordinarily be called monotonous. Such persons find variety disagreeable. They like to repeat the same process over and over again, and day by day their lives follow the same habits. Others hate monotony. These persons find a difficulty in fixing any habits, except the habit of roving. They move from one sort of work to another, or, if they finally settle down to one class of labour, are always changing their employer. Now, in industry some kinds of work are more monotonous than others. The work of a commercial traveller, for example, exhibits considerable variety. On the other hand, the work of a weight-recorder on a weighbridge is fairly monotonous. It is probable that, as we learn more concerning these facts,

[31] *Cf.* F. S. Lee (*The Human Machine and Industrial Efficiency*, pp. 8-9).

it will be possible to utilise our knowledge for the increase of industrial efficiency.[32]

There is another quality concerning which individuals shew great differences, which is of considerable importance to industry. Persons may be divided into two classes according to their type of *attention*. Some have a capacity for extraordinarily concentrated attention. They are able to inhibit all impressions irrelevant to their purpose at any moment, even if such impressions are strong. A friend of mine tells me that he is able to do complicated mental work without trouble even if a piano is being played at the same time in the same room. This would be an absolute impossibility for most persons. In contrast with this concentrated type of attention there is a more comprehensive type, one with a large "spread," as it were, and a person with this type of attention can keep in view at any one moment all parts of a complex situation, and re-act to one in particular, when the demand arises, without losing grasp of the others. Such a type of attention is, perhaps, very useful for the tramcar driver: a man with the concentrated type might attend too much to some one point in the traffic. Neither type can be said to be the better. They are simply different; and for some kinds of industry one is the more suitable, while for other kinds of industry it is the other that is required. This

[32] *Cf.* F. B. and L. M. Gilbreth, *Applied Motion Study* (pp. 174-182).

difference between individuals is an extremely important one from an industrial point of view. Besides persons who exhibit in an especial degree one or other of these two types of attention, there are, of course, those whose capacity for continuously attending, with whatever type of attention, is very poor.

I have referred to four types of individual differences, namely, differences in respect of (*a*) the special senses,—sight, hearing, touch, and so on; (*b*) motor capacity; (*c*) attitude towards monotony and variety, and (*d*) type of attention. It does not need much reflection to enable us to see that the tendency of industry towards specialisation makes such individual differences as exist in connection with these processes of great industrial importance. In my next lecture I shall endeavour, by the help of concrete illustration, to make this fact still clearer, and to shew that individual differences can be used as a practical basis for selection of workers. It is only necessary to add here that the individual differences I have discussed in no sense exhaust the differences between persons; [33]

[33] For instance, I have not mentioned sex differences, although some of these are obviously relevant to industry. An introduction to the whole question of individual differences may be obtained in E. L. Thorndike's *Educational Psychology* (1910). Various highly interesting sections on the subject will be found in F. Galton's *Enquiries into Human Faculty* (Everyman's Library). *Cf.* also *The Science of Labour and its Organisation* (pp. 89-93), by Dr. Josepha Ioteyko (1919). For sex differences, W. I. Thomas' *Sex and Society* (especially chapter I.) may be consulted. The literature on the whole question is, of course, very extensive.

and that what I have said is intended to give a general impression and not a summary of our knowledge concerning them.

Lecture III.

SELECTION OF WORKERS ON THE BASIS OF NATURAL FITNESS

§ 1

The Object of Selection

While the object of selecting workers on the basis of natural fitness will appear differently from different points of view,—the employer, for instance, regarding it in a rather different light from that in which it is seen by the man who is to be selected,—it may nevertheless be stated in a fairly impartial way. This form of statement must, of course, be in general agreement with the aim of industrial psychology as defined in the first lecture (pp. 26 and 34).

In general terms, then, the object of selection would be to increase the output from the expenditure of any given amount of human energy, or, put in the alternative form, to obtain a given output from the least possible expenditure of human energy. Briefly stated, the impartial idea at the basis of selection for vocations is the reduction to the minimum of certain forms of *waste*.

From what was said at the end of last lecture, it will probably be admitted that selection of

workers on the basis of fitness would effect a considerable saving in human energy, as well as in other things considered valuable. In order to realise this more fully, consider how, at the present time, a workman's vocation is usually determined. A boy leaves school, and thinks of beginning work. What does he do? Generally speaking, neither he nor his parents ever think of enquiring for what he is specially suited; but the boy takes any job of which he happens to hear. In the next street is a man who wants a plumber's apprentice. The boy knows that a plumber's wages are high, and, without realising that he may have a special natural aptitude for quite another kind of occupation, he sets to work at plumbing, and keeps to it throughout his life. That boy *may* have had a special aptitude for the work of a clerk, in which capacity he could possibly have risen to the position of chief accountant in a large bank. He *may* have had no liking for the work of a plumber. But plumbing offered itself when he first sought work, and he took it. On the other hand, in some bank there may be a clerk who sought for work in just such an "accidental" manner as that in which this boy took to plumbing, and who has no special aptitude for the duties of a clerk. This man would, possibly, like to be a plumber and work with his hands. The two men thus spend their lives in work other than that for which they are most fitted.

Of course, in certain instances an employer

virtually attempts selection by trying his employees at various kinds of work ; this is always a possibility in factories where various kinds of tasks are performed. In a certain pencil factory, for example, a woman was required to repeat day by day the operation of picking up twelve pencils from a pile with one hand. This had to be done in one movement, and no more and no fewer than twelve pencils were to be taken up. It is stated that some women can do this and some cannot. Many cannot perform the feat even after numerous attempts : others learn it almost at once. In cases such as this, some selection can be made by trying various employees until those are found who are suited for the required task.

Considering the altogether planless manner in which industrial vocations are now ordinarily entered upon, however, it is only likely that, distributed through society as a whole, there are numerous vocational misfits such as I have suggested : men who are plumbers but who might better be clerks, and *vice versa*. And the obvious result must be a considerable amount of *waste*. The clerk takes two hours to do a piece of work which the plumber could do in one hour ; and the plumber's three-day job could, possibly, be finished by the clerk in one day.

The utilitarian value of selection should not, however, be allowed to extrude completely from our minds its more ideal value. In so far as a

man does the work for which he is naturally most fit, he works easily and with relatively little fatigue, since he moves along the lines of least resistance. As was seen in last lecture, reduction of industrial fatigue has a utilitarian value ; but it has a perhaps higher value in that it probably results in an increase of what the Americans term "Happiness Minutes." It seems likely, also, that, even in conditions of industry such as exist at present, selection of workers will increase the number of operatives who find an *interest* in their work. It is true, to some extent at least, that we enjoy doing what we are able to do well.

There is one special object of selection that is not obvious from the definition given, although it would be included in it. This is that in some instances selection effects an actual saving of *life*. I have already mentioned the present application of psychological tests to railway men,—engine drivers and others,—tests applied for the purpose of excluding men whose sight is poor or who are colour-blind. About four per cent. of the population of Western countries, it has been estimated, are colour-blind. Some colour-blind people cannot distinguish red from green ; others cannot distinguish blue from yellow. The ability of either red-green or blue-yellow colour-blind persons to distinguish between different *shades* of colour generally is also very poor. Now, it is obvious that the man who has poor sight, or who cannot distinguish red from green nor blue from yellow, should not be connected

with certain departments of our railway or tramway systems, and that he should be excluded from certain other transport departments also. The faculty of good sight is as important for an officer on a ship's bridge as for a driver on a railway engine, and he, too, should therefore be subjected to examination in that respect. It is perhaps equally obvious that in certain cases *hearing* should be made the basis of selection. It would plainly be absurd to allow, as an operator at a telephone exchange, a girl whose hearing is defective. It is scarcely less obvious that a ship's officer should have good hearing. In the foggy conditions which frequently prevail in certain seasons of the year over certain seas, navigation is attended with special difficulties, and the ship's officer has often to determine his immediate course by his localisation of the foghorns which he hears around him. In such conditions, no ship in a dangerous position can be seen until it is too late to avoid a collision. Consequently, good hearing becomes a necessity.[34] Experimental psychology has brought to light many interesting facts concerning the localisation of sounds. For example, it has been proved that if the head be kept perfectly motionless (the subject being blindfolded), and sounds be made, sometimes immediately in front of, and sometimes immediately at the back of, the head, it is extremely difficult to determine the exact

[34] During the war a great development has taken place in mechanical and electrical technique for determining the localisation of sounds.

localisation of any particular sound; that is, it is often thought that a sound made just in front of the nose really comes from behind the head. It is known, also, that persons are frequently less keen of hearing in one ear than in the other, and that sometimes one ear may be good while the other is entirely deaf. It has been found that such differences have an important influence upon the ability to localise sounds. A person partly deaf in one ear has special difficulty in localisation of sound, and often makes mistakes when he has nothing but his hearing to depend upon. Consequently, it is reasonable to demand that those who are to be entrusted with our lives and property at sea should not suffer from such a disability as defective hearing. A demand that all ship's officers should pass a sound-localisation test, not once, but fairly frequently, is therefore not unreasonable; and the principle involved is precisely the same as that which makes society *demand* that an engine-driver should pass a psychological test for sight and for colour-discrimination.

Optical and auditory tests for railwaymen and ship's officers are definitely psychological, and the justification of the application of these tests in order to exclude the unfit, such exclusion effecting a saving of life, is not likely to be questioned. And the general object of such selection might properly be said to be the prevention of waste.

§ 2

Early Attempts at Selection

Attempts to carry out the application of the idea of selection in spheres in which a saving of life was not *directly* involved were first made in America. Two movements arose there independently in recent years, both tending towards the same goal. Mr. F. Parsons, of Boston, conceived the idea that youths might be given some advice at the end of their school years as to the sort of work they should do.[35] On questioning boys about to leave school, he found that their ideas of the industrial world into which they were soon to enter were of the crudest, and that none had even thought of asking if he had a special fitness for any kind of work. A small office was therefore opened in Boston in 1908, and this developed into a kind of vocational bureau. Here, on leaving school, boys were given some general advice, confined largely to information about supply and demand for labour in various industries. The boys were also advised to choose one employment rather than another in accord with their answers to such questions as these :

"What are your powers of attention, observation, memory, reason, imagination, inventive-

[35] See *Choosing a Vocation*, by F. Parsons (1909) ; referred to by Hugo Münsterberg (*Psychology and Industrial Efficiency*, Ch. V.).

ness, thoughtfulness, receptiveness, quickness, analytical powers, constructiveness, breadth, grasp ? "

" Do you like to be with people and do they like to be with you ? "

" Do you smile naturally and easily, or is your face ordinarily expressionless ? "

" Is your will weak, yielding, vacillating, or firm, strong, stubborn ? "

While this bureau did some useful pioneer work, those interested in it gradually came to realise that their knowledge of individuals would have to be much more definite, if the advice tendered to boys was to be of very great service. It was realised, in fact, that the psychologist, with the methods of the psychological laboratory for comparing capacities, alone could give the required knowledge.

About thirty years previously there had arisen the beginning of what is now termed "scientific management." The originator of this movement was Mr. Frederick W. Taylor, an engineer, whose work and methods will be dealt with in my next lecture. As a rule, the "scientific manager" has been an engineer, and his task has been to eliminate *all* possible waste from industrial concerns. The methods adopted professedly with this aim in view have been various, and sometimes devious; but they included even from the first some selection of

workers on the basis of natural fitness, although the methods used for deciding fitness were often very crude. There was nothing crude, however, in the method of selection used in the following case.

In a certain bicycle-ball factory, 120 girls were employed in inspecting balls.[36] They were required to place the balls in a row upon the back of the left hand in the crease between two of the fingers, and, while rolling them over and over, to inspect them closely for flaws, and to pick out defective balls with a magnet held in the right hand. The examination of the balls was made in a very strong light. The work required good sight, which had to be *rapid*, and it demanded, further, a great readiness *to act upon impressions*, that is, to pick off a defective ball with a magnet *immediately* it was perceived to be defective. The manager, Mr. S. E. Thompson, recognised that the two important points for the work were a quick perceptive capacity and an ability for rapid motor responses.

Now, a person's response to an impression is called, in technical psychological language, his *reaction* to that impression; and the average time it takes him to make a reaction is called his *reaction-time*. In the psychological laboratory, certain pieces of apparatus have been adapted to the purpose of measuring and comparing the

[36] This case is given by F. W. Taylor in *The Principles of Scientific Management* (pp. 86-97). Quoted by Münsterberg (*Psychology and Industrial Efficiency*, Ch. VI.).

reaction-times of different persons. By means of the chronoscope, which may be included in this apparatus, it is possible to measure reaction-times in thousandths of seconds. A person is asked, for example, to press a button as soon as he sees a red flag in a small window; and the average interval between the appearance of the flag and his pressure of the button is his reaction-time.

Fig. V. shews a reaction-time apparatus. A chronoscope (CH) is to be seen in the upper right-hand part of the figure; while on the lower left-hand side of it is to be seen that part of the apparatus in which *sight* signals may be exposed. This signal-exposing mechanism consists of a vertical panel with a window in its centre. In the figure, this window is shewn *unscreened*, and the letter Z is to be seen in it. Before a reaction-time is taken, however, a screen covers the window; and the vertical panel presents to the "subject" a uniformly coloured surface, generally black.

On the lower right-hand side of the figure, resting upon a table, is a Morse key which the subject presses, in this case, *prior* to the appearance of the signal, his *reaction* here consisting in removing this pressure when the signal is exposed. This person sits with his hand pressing the key (K), having his eyes directed towards that part of the vertical panel in which the letter Z is here to be seen,—though, of course, he sees simply a uniformly coloured surface.

By turning the handle of the commutator (C), it is possible for the experimenter to release the

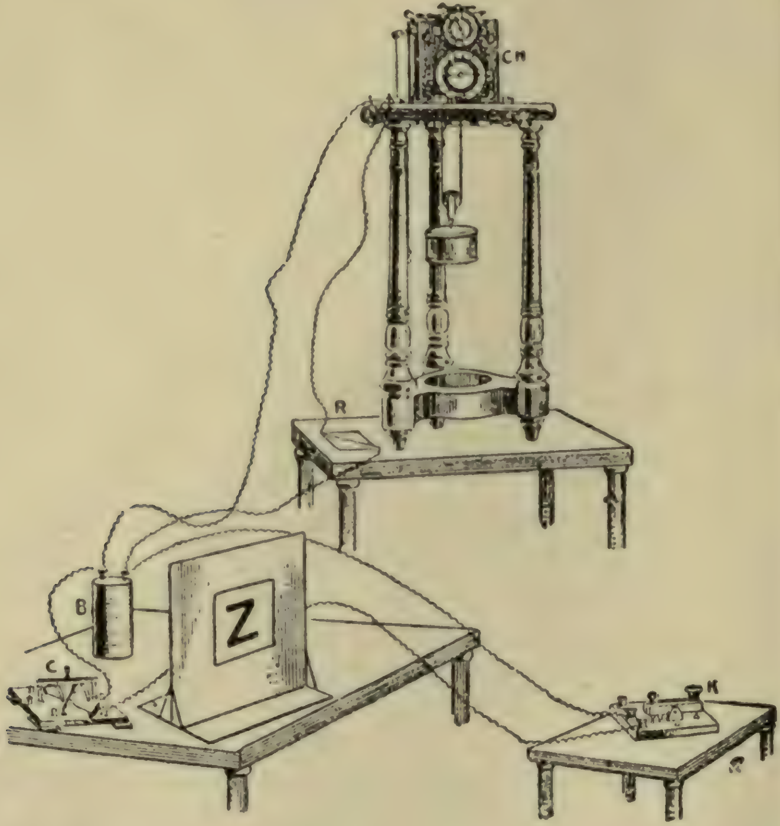

FIG. V.

One form of Reaction-time Apparatus. With this arrangement, the circuit of the chronoscope must be of high resistance, which it may be made by introducing a rheocord into it, say, at R. (B = cell).

screen covering the window at Z, thus exposing the signal, and *to start* the chronoscope at the same moment. By taking his hand from the key

(K), the subject *stops* the chronoscope. It is therefore easy to determine the time occupied by any person in reacting to a signal given in this way. We have only to read the chronoscope before dropping the screen and again after the subject, by taking his hand from the key, has stopped it, and then subtract the first reading from the second. The time can be determined in thousandths of seconds.

Reaction-time experiments can be varied almost indefinitely. For instance, the signal given may be visual, auditory, or tactual (with appropriate apparatus); and it may be varied considerably even when limited to what can be experienced through "one sense." Thus, if it is decided that the signal is to be a visual one, we may make it, say, a single colour, a single word, a picture, and so on. Again: we may use two signals and two keys, instructing the subject to press one key with the left hand and the other with the right hand, and to remove the left hand if one signal is given, the right hand if the other signal is given. And so on.

It has been found, as a result of numerous experiments in the psychological laboratory, that the reaction-times of different individuals differ enormously; and with this fact Mr. Thompson was acquainted. Now, in the examination of the bicycle-balls, reactions, in the technical psychological sense, were required from the girls: that is, the girls had to *put* the

point of a magnet to a ball as soon as they *perceived* a defect in it. Consequently, the natural differences between the girls in respect of their reaction-times was here a matter of great importance. Their reaction-times were therefore investigated, and those whose reaction-times were relatively long were dismissed. This involved the dismissal of some of the most intelligent, hard-working, and trustworthy girls. The principle adopted was that only those girls should be employed whose reaction-times were relatively short. The industry said, in effect: "I demand certain qualities of these girls, and only those who have these qualities can be employed by me." What were the results ?

They were extraordinary enough. It soon became clear that the work was being done much more rapidly than formerly. As it seemed that fatigue had a considerable effect in decreasing the rate of work, the management reduced the hours from ten and a half to eight and a half per day. It also allowed the girls two days off per month, to be taken when they wished. Notwithstanding this decrease in the actual time for work, 35 girls finally produced as much output as the 120 had originally produced, while the accuracy of the work was two-thirds greater than before. The management, further, increased the wages of the girls by nearly 100 per cent., and even then the cost of the production of the bicycle-balls was largely decreased.

This case is instructive for various reasons. The operation of fatigue in the longer working day is of considerable interest, although, as other factors were varied when the day was shortened, the effect of a decrease of fatigue upon the quantity and quality of the output cannot be exactly estimated. That this effect was not small, however, is suggested not only by the facts stated above, but also because fatigue increases reaction-time. It is common for a moderate amount of fatigue to cause a doubling of a person's reaction-time ; [37] and this would be of great importance in the present instance. In fact, the conclusions drawn, in the preceding lecture, from actual industrial records, about the detrimental effect of fatigue in causing accidents and lowering quantity and quality of work, might have been drawn equally well from a consideration of the effect of fatigue upon reaction-time. Much of the work involved in present-day industry is reducible to reactions. It has been shewn by various experiments that fatigue both increases reaction-time and the proportion of incorrect reactions. The immediate deduction from these facts is that, wherever labour is reducible to reactions, fatigue will lower the quantity and quality of its output, and in certain instances lead to accidents.

Another important question which arises here is what is to happen to the 85 girls who were

[37] See A. Mosso's *Fatigue* (pp. 204-205).

dismissed as the result of this application of science to industry. With such questions as this, admittedly important, I shall deal in my last lecture.[38] It may be said here, however, that by being dismissed from the bicycle-ball factory because of natural unfitness for the work required of them, these girls were not thereby proved incompetent *generally*. Some of those dismissed were especially intelligent; and the presumption is that there would be other work for which such girls would be fitted by nature. There certainly are some kinds of work which require *intelligence* rather than a quick reaction-time, and in doing such work these girls would find their places.

A third point is this. The capacity required from the girls in the bicycle-ball factory was highly *specialised*, and relatively very simple. In these respects, it is similar to much other industrial work, and selection for such work is comparatively easy. But there are many sorts of task in industry at present where the capacities required are, if still specialised, also highly complicated: that is, industrial processes often demand, not one, but *many* specialised capacities. Where this is so, it may seem, at first, almost impossible to apply the principle of selection, since it may seem almost impossible to determine relative fitness. This, however, would be a mistaken idea. In possible methods for deter-

[38] See below (pp. 237-243).

mining relative fitness for complicated work, two principles may be distinguished. The first is the breaking of the complicated labour processes into as many distinct parts as possible, and the testing of prospective operatives with respect to each of them, then averaging results. The second is the selection of the *central*, or most important, part of the process, and the testing of individuals for capacity in this part. I shall call these two principles the *each-capacity principle* and the *central-capacity principle*. Whether the one principle or the other be adopted in any case will generally depend upon the precise character of the work. I shall give an instance illustrating the use of each.

§ 3

Principles by which Selection may be made when Work is of a Complicated Character

(1) I shall begin with the *each-capacity principle*, attempting to illustrate its possible application by reference to the work of the operator in a telephone exchange. This work is highly complicated, and, in certain respects, typical of many industrial occupations. In order to explain the demands made upon "the telephone girl's"[39] psycho-physical constitution,

[39] There are male as well as female Telephone Operators.

it is necessary to give some account of the mechanism she operates.

The telephone operator is, during her work, seated before a continuous upright "switchboard" which, in any large exchange, extends in the form of a U round three sides of a large room. The bottom of this switchboard is about on a level with the operator's elbow, while the top rises considerably above her head. It is divided, firstly, into vertical sections, before each of which one operator is situated. These sections run from the top to the bottom of the switchboard, and are about eighteen inches in width. As occasion requires, an operator must stretch so as to reach any point in the upper parts of three vertical sections, namely, that immediately before her and that immediately on either side.

Each vertical section of the switchboard is divided into an upper and a lower panel, the lower one being much the smaller. This lower panel contains the terminals of all the subscribers for which the girl before it is immediately responsible. These terminals consist of small holes in a metal surface. Over each hole is a tiny lamp. The upper panel of the vertical section contains nothing but small holes, with which it is honeycombed, and the numbers corresponding to each. There are no small lamps in this upper panel. The holes, here, are the terminals of all lines connected with the

exchange, and, generally speaking, they are repeated once every three vertical sections,—so that each girl may be able to reach all lines.

From the bottom of the switchboard there extends horizontally a shelf, which varies, in different exchanges, from six inches to eighteen. This holds different sorts of mechanism. Firstly, on the outer edge, that is, nearest to the operator, there is a row of small levers. Nearer to the switchboard there are two rows of tiny lamps similar to those above the subscribers' terminal holes. Finally, there are, nearest to the switchboard, two rows of small metal plugs, only the tops of which extend above the shelf. The plugs and the tiny lamps are co-ordinated and arranged in pairs: there is a pair of lamps to each pair of plugs. Further, each of the plugs constituting any pair is connected to the other by a cord carrying a wire. When not in use this cord hangs below the shelf.

The entire arrangement is not the same in all exchanges, while in many there are various additions to that described. Thus, in Sydney *Central* there is a set of electric buttons in the left-hand corner of the shelf-section belonging to any girl, by means of which it is possible to call other exchanges. There are also metal pencils which must be pressed for the registration of "calls."

In addition to the apparatus in front of the operator, there is a receiver, with a mouthpiece

attached, strapped over her head, so that she may have her hands free while hearing and speaking.

How, now, is the mechanism operated? Suppose that a subscriber wishes to ring up. He first takes the receiver from its hook. This makes the small lamp above his terminal glow, and, in some systems, starts a clicking in the operator's ears. The glowing of the signal lamp is the sign to the girl that she is being called. To get into communication with the calling subscriber, as she must, she has to take one of the metal plugs and put it into the hole immediately below the glowing lamp, at the same time pushing forward one of the small levers on the horizontal shelf. When this is done, she says "Central," "Redfern," etc., and the subscriber tells her the number he wants. She then takes the companion plug to the one she has used, and, if the subscriber called is not engaged, puts this plug into the terminal hole of that subscriber in the *upper* panel of the switchboard.

Immediately this is done, the pair of lamps on the horizontal shelf corresponding to the pair of plugs that has been used begins to glow. This glow ceases as soon as the subscriber who is called lifts his receiver from its hook, and there is no further glow while the conversation continues. When it is ended, however, and the receivers are put on their hooks once more, the glow appears again, and this is the signal to the

girl that the conversation is over. She then takes the plugs from the two holes and lets them slip back again into their rest places, the cord dropping beneath the shelf.

At some stage in this process the call has to be registered in some way or other, often by writing it on a slip of paper. In Sydney, also, the operator is supposed to make a note if a subscriber rings up an engaged number, and as soon as it is free, to ring up the subscriber and inform him of the fact. This she sometimes does.

I have now described the process to be gone through when one subscriber rings up. Even one such process is obviously involved; but it must be remembered that each girl is responsible for a number of different subscribers,—in Sydney about 120,—and that many of these may be ringing up at the same time. Thus, at any moment a girl may see on the switchboard before her some dozen glowing lamps, which, she knows, indicate that some twelve subscribers are impatiently waiting to be attended to. If possible, she must "clear" the board in the order in which it has become "loaded"; but with a dozen lamps glowing before her, this is almost impossible, although she knows that, as a result, the one of the twelve subscribers who rang first may be kept waiting until he gets angry. Further still, there are supervisors attached to small groups of girls. A supervisor constantly walks up and down behind her group, watching for

carelessness or neglect, and helping to clear over-loaded boards by taking the calls to girls relatively free. Thus, the telephone operator has immediately before her a mechanism to the impersonal developments in which she must keep herself adapted; she has a consciousness of the waiting subscribers at the end of the lines which shew the glowing lamps; and a consciousness of the supervisor behind her.

From this brief sketch it is probably clear that the capacities required of the telephone operator are special and precise. For instance, a telephone operator must possess good hearing and good sight and power of speech; a capacity for retaining in memory, for a brief period at least, a set of digits when these have been heard; a capacity for visual and motor memory, to enable her to realise automatically on what part of the switch-board a called number is situated, and to plug the hole corresponding to that number, and not one, say, next to it; a capacity for order memory, so that, as far as possible, subscribers will be attended to in the order in which they have rung up; and so on. It has been stated that the simplest kind of telephone operating requires *eleven* distinct and different processes, while in many exchanges fourteen are required: that is to say, all these different processes are involved whenever a call is made.

It is natural to suppose that in such complicated and, at the same time, highly specialised

work, it would be found absolutely necessary to select workers on the basis of natural fitness; and, as a matter of fact, some selection of telephone operators seems to have been practised ever since the beginning of the telephone business in 1876. The selection has usually been made by medical men, and has aimed at the exclusion of such persons as possessed some obvious defect, such as poor sight, or poor hearing, or weak muscles which would not bear the strain of much stretching. Good general health has also as a rule been demanded of applicants for positions in telephone exchanges. Notwithstanding such selection, two interesting points must be noted.

Firstly, it was not infrequently found by American companies that, even after a girl had passed the medical tests successfully, she proved altogether incompetent, and had to be dismissed. This was discovered as a rule only after a considerable amount of training had been given these girls, and the training in these cases, from the point of view of the companies concerned, represented loss. Such loss could have been avoided only if the directors had been able to pick out those who would be incompetent, at the time they applied for the positions; but this was not possible by the usual medical tests. And, indeed, the only tests that would be efficient here would be psychological tests.

Secondly, the effect of telephone operating upon the health of those engaged in this work has often, in the past, been very bad. This was

established beyond question by two investigations made within fairly recent years. The first of these was carried out by a Royal Commission "on a Dispute Respecting Hours of Employment between the Bell Telephone Co. of Canada, Ltd., and operators at Toronto." The report of this investigation was published in 1907. The second had as its object a general enquiry concerning work connected with the telephone business, and was made by the United States Bureau of Labour. Its conclusions were published in 1910. The Committees of enquiry in both cases interviewed physicians on the question of the effect of the occupation of telephone operating upon the health of operators. The verdict of the doctors was definite and damning.[40] For instance, Dr. Charles R. Clark, medical superintendent of the Toronto Asylum, stated that the work "requires a mental effort every time. Nervous strain is intense and would react on the physical health in a marked way after three years' service, and might pass on to the next generation in a more striking way than even in the present generation. I am basing that statement on my every-day experiences with just such cases, having an experience of that kind of thing for several years." Again, Dr. J. M. McCallum, Professor of Therapeutics at Toronto University, stated that "the result of this work would be nerve fag, and might be a nervous

[40] See Josephine Goldmark's *Fatigue and Efficiency* (pp. 35-48).

breakdown. . . . We know practically that changes in illumination from dark to light do irritate the optic nerve, and that is going on all the time. . . . Flashing of the light has an irritating effect and is in that way injurious. The nerves governing the extra ocular muscles which focus the eye upon the object looked upon, are the nerves where the greatest part of the strain comes. The sound kept up for hours must have an effect on the auditory nerves, and if for long hours, an injurious effect might cause deafness. The possibility of receiving shocks would add to the nerve strain; effect on vocal organs not much. The effect upon the nervous system is through the nerves of the eye and the auditory nerves; reaching is subsidiary; operating together causes the difficulty."

Much similar medical evidence was given. It was, as a rule, based upon a direct experience of cases of suffering caused by telephone operating. The bad effects of the occupation seemed, to the members of the Canadian Commission, to be due especially to the long hours of work, and in this they were almost certainly correct. A day's work of nine or ten hours was, at that time, common for telephone operators, while a day of twelve hours was not infrequently met with, and a day of fifteen hours not unknown. The Commission, therefore, limited the total number of hours per day for women operators to seven "broken by several relief periods and spread over a period of nine hours." It added:

"In our opinion a day of six working hours spread over a period of from eight to eight and three-quarter hours, and under as favourable conditions as may be expected in an exchange doing a large business, is quite long enough for a woman to be engaged in this class of work, if a proper regard is to be had for the effect upon her health." It is interesting to note here that the working hours at Sydney *Central* are approximately six per day.

Even with a short working day, however, the strain involved in telephone operating may be considerable, although the health effects may not be what they have been in the past. How, then, might this strain be decreased? In various ways, no doubt; for instance, by lessening the number of subscribers for which each girl is responsible; by giving frequent rests; and so on. But perhaps the most effective method for lessening this strain would be to select as operators those who are most gifted for this kind of work, such selections to be carried out with great care and thoroughness. This would also have the effect of eliminating, on application for this work, those who would eventually be shewn to be incompetent for it. A director of a telephone system tells me that if a modification of mechanism is introduced which will effect a saving of a small part of a second in the time necessary for the performance of any one of the operations required for each call, it is looked upon as an achievement. It has hardly

been recognised that such a saving could easily be effected by appropriate selection of operators.

I shall now sketch briefly how such a selection could be made by means of *the each-capacity principle.* Let us *assume* that the capacities required for operating are those shewn in the following table; that psychological tests have been devised for indicating those persons who possess these capacities in a high degree; that A and B are two applicants for the position of telephone operator; and that A and B have been subjected to the various psychological tests, and their respective capacities under each head expressed as percentages of certain standard capacities. We then have at our disposal such facts as the following (the percentages here being hypothetical).

Table VIII.

CAPACITY.	A	B
Sight	80%	90%
Hearing	70%	70%
Speech	100%	90%
Reacting to light by putting a plug into a hole with right hand ..	50%	30%
Reacting to light by moving a lever with left hand	60%	35%
Accuracy of movement for plugging hole with right hand	75%	30%
Accuracy of movement for plugging hole with left hand	60%	20%
Memory for figures heard	30%	60%
Comprehensiveness of attention ..	60%	40%

If, now, we wish to know whether A is naturally more fit for telephone operating than B, we must add together their scores, and either compare the totals, or the averages of each for all capacities. A's score is 585, B's 465; the average capacity of A is represented by 65, that of B by 51·67. That is, A is more fit for the position than B.

It must be remarked that, in order to proceed by this method, it is, of course, necessary that an applicant's achievement in any test should not be zero. If it were, he would be unfitted *altogether* for the work, even if in other tests he did excellently: that is to say, he could never carry out the *whole* of the process required of him. In fact, any person's achievement with regard to any capacity would need to reach some minimum, to be determined practically. It must be added, also, that the above is not an exhaustive list of the special capacities required for telephone operating.

Attempts to adapt psychological tests for the selection of telephone girls along the lines indicated have already been made, and are of some interest.[41] I shall not discuss them, however, partly because they were not carried out with thoroughness, and therefore did not yield any very useful practical formulas, and partly because "the automatic" will in the future do

[41] See Münsterberg's *Psychology and Industrial Efficiency* (Ch. X.).

away with the necessity of telephone operating to a very large extent. It may, indeed, be said that, for this reason, the foregoing discussion has little value. It is the principle used in selection for such complicated work, however, which is of importance. Since the mechanism of a telephone exchange, although complex, is relatively easy to comprehend, *the each-capacity principle* of selection can readily be made clear in connection with telephone operating. That is why I have chosen this work for the purpose of illustrating that principle, the further possible extensive application of which will, I hope, now be obvious.

(2) I pass to an instance of complicated work in which the method adopted in attempting to select fit men was what I have called *the central-capacity principle*. The occupation was that of a driver on an electric street car. The attempt that was made to select those best fitted for this kind of work is highly interesting for various reasons, and I shall therefore state it in some detail. It was carried out by the late H. Münsterberg, Professor of Psychology at Harvard University, U.S.A., and it will perhaps be found most interesting if I quote from the account that he has given of it. He says:[42] "The problem of securing fit motormen for the electric railways was brought to my attention from without. The accidents which occurred through the fault, or

[42] *Ibid.* (Ch. VIII.).

at least not without the fault, of the motormen in street railway transportation have always aroused disquietude and even indignation in the public, and the street railway companies suffered much from the many payments of indemnity imposed by the court, as they amounted to thirteen per cent. of the gross earnings of some companies. Last winter (1912) the American Association for Labour Legislation called a meeting of vocational specialists to discuss the problem of these accidents under various aspects. The street railways of various cities were represented, and economic, physiological, and psychological specialists took part in the general discussion. Much attention was given, of course, to the question of fatigue and to the statistical results as to the number of accidents and their relation to the various hours of the day and to the time of labour. But there was a strong tendency to recognise, as still more important than the mere fatigue, the whole mental constitution of the motormen. The ability to keep attention constant, to resist distraction by chance happenings on the street, and especially the always needed ability to foresee the possible movements of the pedestrians and vehicles were acknowledged as extremely different from man to man. The companies claimed that there are motormen who practically never have an accident, because they feel beforehand even what the confused pedestrian and the unskilled chauffeur will do, while others relatively often experience

accidents of all kinds because they do not foresee how matters will develop. They can hardly be blamed, as they were not careless, and yet the accidents did result from their personal qualities; they simply lacked the gift of instinctive foresight. All this turned the attention more and more to the possibilities of psychological analysis, and the association suggested that I undertake an enquiry into this interesting problem with the means of the psychological laboratory. I felt the practical importance of the problem, considering that there are electric railway companies in this country which have up to fifty thousand accidents indemnity cases a year. It therefore seemed to me decidedly worth while to undertake a laboratory investigation. . . .

I abstracted from the study of single elementary functions and turned my attention to that mental process which after some careful observations seemed to me the really central one for the problem of accidents. I found this to be a particular complicated act of attention by which the manifoldness of objects, the pedestrians, the carriages, and the automobiles, are continuously observed with reference to their rapidity and direction in the quickly changing panorama of the street. Moving figures come from the right and from the left toward and across the track and are embedded in a stream of men and vehicles which moves parallel to the track. In the face of such manifoldness there are men whose impulses are almost inhibited and who instinc-

tively desire to wait for the movement of the nearest objects ; they would evidently be unfit for the service, as they would drive the electric car far too slowly. There are others who, even with the car at high speed, can adjust themselves for a time to the complex moving situation, but whose attention soon lapses, and while they are fixating a rather distant carriage, may overlook a pedestrian who carelessly crosses the track immediately in front of their car. In short, we have a great variety of mental types of this characteristic unified activity, which may be understood as a particular combination of attention and imagination."

The question thus was to devise some sort of test which would make it possible to know which men possessed "the particular combination of attention and imagination" required, and which did not. This test had to satisfy two general conditions. Firstly, it would be efficient only if it shewed good results with reliable, and bad results with unreliable, drivers ; and, secondly, it should arouse in the men the feeling that their experience during the test was similar to that when actually driving the car in the street. A test which seemed to satisfy these two conditions, and was finally decided upon, was the following.

"The street is represented by a card 9 half-inches broad and 26 half-inches long. Two heavy lines half-an-inch apart go lengthwise through the centre of the card, and accordingly

a space of 4 half-inches remains on either side. The whole card is divided into small half-inch squares which we consider as the unit. Thus there is in any cross-section 1 unit between the two central lines and 4 units on either side. Lengthwise there are 26 units. The 26 squares which lie between the two heavy central lines are marked with the printed letters of the alphabet from A to Z. These two heavy central lines are to represent an electric railway track on a street. On either side the 4 rows of squares are filled in an irregular way with black and red figures of the three first digits. The digit 1 always represents a pedestrian who moves just one step, and that means from one unit into the next; the digit 2 a horse, which moves twice as fast, that is which moves 2 units; and the digit 3 an automobile which moves three times as fast, that is, 3 units. Moreover the black digits stand for men, horses and automobiles which move parallel to the track, and are therefore to be disregarded in looking out for dangers. The red digits, on the other hand, are the dangerous ones. They move from either side toward the track. The idea is that the man to be experimented on is to find as quickly as possible those points on the track which are threatened by the red figures, that is, those letters in the 26 track units at which the red figures would land, if they make the steps which their number indicates. A red digit 3 which is four steps from the track is to be disregarded, because it would not reach the

track. A red digit 3 which is only one or two steps from the track is also to be disregarded, because it would cross beyond the track if it took three steps. But a red 3 which is three units from the track, a red 2 which is two units from the track, and a red 1 which is one unit from the track would land on the track itself; and the aim is quickly to find these points. The task is difficult, as the many black figures divert the attention, and as the red figures too near or too far are easily confused with those which are just at the dangerous distance."

A diagram illustrating the card used by Münsterberg is given in Fig. VI. In this figure, digits in heavy black type are substituted for the red digits in the original experiment. It will be noticed that the dangerous letters here are D, I, J, O, P, S, W, Y. At B, for instance, the automobile will cross the track in front of the car without danger: similarly for the two automobiles at Z. On the other hand, G is not dangerous, because the car will cross this square before the pedestrians reach the track: and similarly for U and V, etc. There is no danger at X, although both an automobile and a pedestrian are crossing "the street" at that point; for the automobile will cross before the car reaches X, and the car will pass X long before it is reached by the pedestrian.

	3	3		Z	**3**	**3**		2
3	3	**2**		Y				2
	3			X		**3**		**1**
		2	**1**	W			3	
	3			V			**1**	**1**
1			3	U				
				T		3		**3**
3		**2**		S				
				R	3	3		3
		2		Q	3			3
	3			P			**2**	**1**
3				O	**1**	**1**	3	
	3		**3**	N				**3**
	3	**1**		M		2		3
	3			L				
3				K	**2**			
	3	3		J			3	**1**
	2		**1**	I				
	2	2		H	3	**3**		
1	**1**	**1**	3	G				
				F			3	
3				E		**3**		
		2		D		2		3
		3		C			3	
3			**3**	B		3		
	2			A	3	**1**		**3**

FIG. VI.

The kind of card used in Münsterberg's experiment. (Reduced size: see pp. 134-135).

The next task was to arrange a mechanism for the use of this card as a test. Finally, the following arrangement was adopted. "Twelve such cards, each provided with a handle, lie one above another under a glass plate through which the upper card can be seen. If this highest card is withdrawn, the second is exposed, and from below springs press the remaining cards against the glass plate. The glass plate with the 12 cards below lies in a black wooden box and is completely covered by a belt 8 inches broad made of heavy black velvet. This velvet belt moves over two cylinders at the front and rear ends of the apparatus. In the centre of the belt is a window $4\frac{1}{2}$ inches wide and $2\frac{1}{2}$ inches high. If the front cylinder is turned by a metal crank, the velvet belt passes over the glass plate and the little window opening moves over the card with its track and figures. The whole breadth of the card, with its central track and its four units on either side, is visible through it over an area of five units in the length direction. If the man to be experimented on turns the crank with his right hand, the window slips over the whole length of the card, one part of the card after another becomes visible, and then he simply has to call the letters of those units in the track at which the red figures on either side would land, if they took the number of steps indicated by the digit. At the moment the window has reached Z on the card, the experimenter withdraws that card and the next becomes visible, as a second

window on the belt appears at the lower end when the first disappears at the upper end. In this way the subject can turn his crank uninterruptedly until he has gone through the 12 cards. The experimenter notes down the numbers of the cards and the letters which the subject calls. Besides this, the number of seconds required for the whole experiment from the beginning of the first card to the end of the twelfth, is measured with a stop-watch. This time is, of course, dependent upon the rapidity with which the crank is turned."

The chief results to be taken into consideration were two, namely, (*a*) the time occupied by a man in going through the experiment, and (*b*) the number of danger spots not noticed by him.

Having now elaborated a piece of apparatus which seemed capacle of giving the information desired, Münsterberg tested a number of drivers with it. "In accordance with my request, the company furnished me with a number of the best motormen in its service, men who for twenty years and more had performed their duties practically without accidents, and, on the other hand, with a large number of motormen who had only just escaped dismissal and whose record was characterised by more or less important collisions or other accidents. Finally, we had men whose activity as motormen was neither specially good nor specially bad."

Coming now to the actual procedure in carrying

out the test, it is to be noted that the apparatus was always fully explained to any man before he was asked to use it. "I at first," says Münsterberg, "always shewed the man one card outside of the apparatus and explained to him the differences between the black and the red figures and the counting of the steps, and shewed to him in a number of cases how some red figures do not reach the track, how others go beyond the track, and how some just land in danger on the track. As soon as he had completely understood the principle, we turned to the apparatus and he moved the window slowly over a test card and tried to find the dangerous spots, and I turned his attention to every case in which he had omitted one or given an incorrect letter. We repeated this slowly until he had completely mastered the rules of the game. Only then was he allowed to start the experiment."

It is important to note that the verdict of experienced drivers was that, in going through this psychological test, they had the same feelings as when actually driving. "The necessity of looking in both directions, right and left, for possible obstacles, of distinguishing those which move toward the track from the many which move along the track, the quick discrimination among the various rates of rapidity, the steady forward movement of the observation point, the constant temptation to give attention to those which are still too far away or to those which are so near that they will cross the track

before the approach of the car, in short, the whole complex situation with its demands on attention, imagination, and quick adjustment, soon brings them into an attitude which they themselves feel as identical with that in practical life."

The important question now is: What results were obtained from this test? There was a "*far-reaching correspondence between efficiency in the experiment and efficiency in the actual service.*" This result is subject to certain qualifications which, however, may be neglected, as they do not affect its general character.

It is of some interest to consider the method Münsterberg used for evaluating the numerical results. I shall again state the matter in his own words. "The mere number of omissions alone," he says, "cannot be decisive, as it is clear that no intelligent man would make any omissions if he should give an unlimited amount of time to it; for instance, if he were to spend fifteen minutes on those 12 cards. But this is the same thing as to say that a motorman would not run over anyone if he were to drive his car one mile in an hour. The practical problem is to combine the greatest possible speed with the smallest number of oversights, and both factors must therefore be considered. In the results which I have gathered in experiments with motormen, no one has gone through those 12 cards in a shorter time than 140 seconds, while

the longest time was 427 seconds; on the other hand, no one of the motormen made less than four omissions, while the worst ones made 28 omissions. I abstract from one extreme case with 36 omissions. On the whole, we may say that the time fluctuates between 180 and 420, the mistakes between 4 and 28. The aim is to find a formula which gives full value to both factors and makes the material directly comparable in the form of one numerical value instead of the two. If we were simply to add the number of seconds and the number of omissions, the omissions would count far too little, inasmuch as 10 additional omissions would then mean no more than 10 additional seconds. On the other hand, if we were to multiply the two figures the omissions would mean by far too much, as the transition from four mistakes to eight mistakes would then be as great a change as the transition from 200 to 400 seconds, that is, from the one extreme of time to the other. Evidently we balance both factors if we multiply the number of omissions by 10 and add them to the number of seconds. The variations between 4 and 28 omissions are 24 steps, which multiplied by 10 correspond to the 240 steps which lie between 180 and 420 seconds. On that basis any additional 50 seconds would be equal to five additional omissions. If of two men one takes 100 seconds less than his neighbour, he is equal to him in his ability to satisfy the demands of the service, if he makes 10 mistakes more."

By using the apparatus that has been described, then, and by evaluating the results of the tests in the above-mentioned way, the large general correspondence " between efficiency in the tests and efficiency in the actual service " was obtained. Münsterberg emphasises certain imperfections of his test; but it is fairly clear that, even with these imperfections, it might profitably be used. And apart altogether from this particular test for electric car drivers, we see that the principle of the test is capable of extensive application. Professor Münsterberg concludes his account of this attempt at selection with these words: " There can be no doubt that the experiments could be improved in many directions. But even in this first, not adequately tested form, an experimental investigation of this kind which demands from each individual hardly 10 minutes would be sufficient to exclude perhaps one fourth of those who are nowadays accepted into the service as motormen. This 25 per cent. of the applicants do not deserve any blame. In many other occupations they might render excellent service; they are neither careless nor reckless and they do not act against instructions, but their psychical mechanism makes them unfit for that particular combination of attention and imagination which ought to be demanded for the special task of the motorman. If the many thousands of injury and the many thousands of death cases could be reduced by such a test at least to a half, then the conditions

of transportation would have been improved more than by any alterations in the technical apparatus, which usually are the only objects of interest in the discussion of specialists. The whole world of industry will have to learn the great lesson, that of the three great factors, material, machine, and man, the man is not the least, but the most important."

It must be emphasised that Münsterberg's experiment has been described in detail for the purpose of illustrating *the central-capacity principle* for selection of workers. The interest attaches not so much to this particular experiment, though that is no doubt interesting, but to the principle of it. What I desire to suggest is that this principle may be applied with valuable results throughout a wide field in the industrial world.

It is perhaps necessary here to anticipate a possible objection. It may be said that psychological tests, devised to single out the fit from the unfit applicants for any kind of work, would take no account of a person's capacity to improve with practice. It may be added that the nervousness induced in a person as a result of his being required to undergo a psychological test would make a certain type of man do badly, although men of this type are often excellent workmen. It is known, for example, that some persons do their best work at first, while most never do good work until they get "warmed

up." [43] It may therefore be said that although some particular man, applying for a position as tram-car driver, for example, should do badly at a psychological test, he might improve very rapidly, and, when experienced, find a place in the top rank. The answer to objections such as these is, briefly, that *adequate* psychological tests would take into account the phenomenon of "warming up," and the differences between persons in learning capacity, initial nervousness, and so on. Münsterberg's experiment certainly did not allow for such facts; but he admitted its imperfections. It would only need care, however, to construct psychological tests that are perfectly adequate. Nevertheless, the test used by Münsterberg gave a good general result, even if, as is possible though by no means certain, it did not do justice to some few individuals.

(3) The method by which selection tests are likely to be obtained in the near future is not based entirely on either of the above principles. A number of tests are first chosen because of *apparent* relevance to any given sort of work, and a process of sifting is then carried out to determine which of these are useful and which are not. This sifting process consists of giving the apparently relevant tests to a number of workmen of known different grades of ability for the given sort of work, and of throwing out those tests that do not correlate highly with known capacity. If

[43] *Cf.* above, p. 72.

the tests are to be used for selecting stenographers, for instance, they are first given to a number of stenographers representing different grades of stenographic skill. Thus, 40 stenographers may be given these tests : 10 very good, 10 good, 10 indifferent, and 10 poor. Those tests are then chosen for use in selecting stenographers which best rank *these* stenographers according to their *known* ability. And if afterwards stenographers selected by these tests turn out well, we may suppose that the tests are relatively good tests. By this procedure, much excellent selection work has been carried out in the U.S. Army (1918).[44]

§ 4

The Practicability of the Theory of Selection

I shall conclude this lecture by discussing very briefly the question how far selection of workers on the basis of natural fitness is practicable at the present time.

As regards what it is usual to call unskilled labour, there seems no irremovable obstacle in the way of applying the principle of selection. For instance, there seems no reason why an employer should not, when about to engage men

[44] *Cf.* H. C. Link, *An Experiment in Employment Psychology*, in *The Psychological Review*, 1918 (pp. 116-127).

for specialised work, utilise the services of the psychologist for the purpose of selecting those applicants most fitted for it.[45]

When, on the other hand, it is a question of applying the principle of selection to men already skilled in some trade, the matter is quite different. Generally speaking, it would probably not be profitable to take such men from the work for which they have been trained and put them to other work. Further, even if it were profitable, it might not be just. A man's desires must always be treated with respect, and, even when an attempt is made to "measure" him, it must not be forgotten that he is a person.[46] If a

[45] It is necessary to warn against the use of psychological tests by persons who have had no training, or only a little, in the use of them. It is true that some persons are born psychologists, and that such persons, even without training, will make no great errors in the use of psychological tests, nor in the interpretation of results obtained from them. These persons, however, are not common; and the chances are all against the probability of the men put, by employers, to do the work of testing, being among them. Consequently, the use of psychological tests for selection, except by persons who are trained in their use, will in all probability end in considerable disappointment. It may easily lead to strikes. In any case, as has been pointed out, in the sense in which we may speak of born psychologists, we may also speak of born doctors.

[46] "A man may be physically fitted to be a blacksmith, and according to all laws of a purely physical nature be the choice of scientific management for the job of a blacksmith. The man, however, desires to be a salesman of ribbons, and all the King's horses, and all the King's men, could not get him to put on overalls and swing a sledge. A young man may be scientifically fitted for a task in the town of X, and is earning extra high wages for his efficiency, but he has a sweetheart over in the town of B, and he moves despite the protests of industrial efficiency. . . . I know a very expert mechanic living in the Borough of The Bronx in the city of New York, who refused a position of

plumber were to say, for instance, that plumbing is the one sort of work in all the world which interests him, then his interest should, in an ideal state, have considerable weight attached to it. Probably the interests of men have been, to some extent, determined by the occupations into which they have drifted ; and it is possible that there would be no conflict between talent and interest if selection were made universally at the time a boy begins to work. Possible conflict, however, would, in my opinion, need to be constantly watched for ; and consequently the administration of any system of selection would need to be somewhat elastic. It is highly probable, however, that, if such a system were administered by appropriately trained men, the amount of hardship accruing through conflicts between interest and talent would be infinitesimal compared with that which now results from an

responsibility and high pay in a western city merely because he did not want to live so far away from Broadway. . . . I had a worker refuse to co-operate with me at one time because I assumed that his ideals and my own ideals were identical. I offered him a 50 per cent. bonus for a proportional increase in his production. The job had been standardised, scientific management had been applied to the mechanics of the operation, but the man said : 'I do not want any 50 per cent. bonus. I am satisfied with what I get, and when I want more I will ask for it.' . . . Scientific management would have said 'Fire him !' but he could not be fired. His father had worked in that mill before him, and he had a son starting down in the ranks. He had a home he had been paying for out of moneys advanced by the employer. He was a social factor as well as a productive factor in that mill. Discharging that man might have meant the total disruption of a heretofore harmonious industrial family." M. Chipman, *Efficiency, Scientific Management, and Organised Labour* (pp. 2-3), 1916.

almost entirely unguided method of taking up vocations.

It is thus probable that the attempt to carry out the principle of selection at present in the adult labour world would be faced with certain difficulties, though perhaps of varying importance. Such difficulties would arise partly from the side of the employer,[47] partly from the side of the workman. But it seems to me that there are no difficulties, except conservatism, in the way of applying the principle of selection to boys and girls who are just about to become wage-earners. It may be interesting to attempt a sketch of the way in which such application might be made.

Connected with any educational system,[48] there might be a large Vocational Laboratory. This laboratory would be under the control of psychologists, trained in the use of all kinds of mental tests, and capable of adapting such tests to special sets of conditions. It would be the final function of these men to advise young persons about to start work as to the general direction in which they should seek it. In order to make such advice of the greatest possible value, it would be necessary for the advisory committee to have at its disposal information covering three separate spheres.

[47] *Cf.* R. F. Hoxie, *Scientific Management and Labour* (pp. 7-13, and 113-122); 1915.

[48] Or with a large industrial plant, or a whole industry.

Firstly, it would be necessary to possess the results of the psychological tests carried out upon the boys and girls. The knowledge given by such tests would need to be tabulated systematically and with the utmost care. In this task, the psychologists would probably be helped by taking into consideration the school records of the children, which would be themselves tabulated in certain definite forms by clerks who simply worked up material handed them by class teachers and heads of schools.

Secondly, the actual processes of labour occurring in industry at any time would need to be analysed into their elements, and a knowledge of the special mental and physical capacities required for each sort of process tabulated in systematic form.

Thirdly, it would be necessary to know,—and here economists would be consulted,—what were likely to be the possible developments of this or that industry in the near future. For instance, a youth might have qualities fitting him primarily to be a blacksmith ; but the economist might be able to shew it to be probable that the demand for blacksmiths would in a few years be very small. It might then be well for the yough to decide for the occupation for which he was *next best* fitted, and so generally.

The advisory committee of the vocational laboratory would thus have before it, when advising upon vocations, tables presenting three

different sorts of information: (1) information about the capacities of the persons being advised, (2) information about the capacities required for any sort of labour actually occurring at the time, and (3) information about the probable demands for this or that sort of labour in the near future. I think it is obvious that advice tendered to persons about to begin work, and based upon such information, would be of the greatest value.

Such a vocational laboratory as has been indicated in bare outline might be instituted, to begin with, for dealing with boys who are about to enter upon apprenticeship. In the past type-setting apprentices, for instance, have been accepted only after satisfying certain conditions; and, generally speaking, in any trade an apprentice has been required to satisfy some conditions before being accepted. These conditions, however, have not concerned the special capacities required for the kind of work in question in any particular case. It has been a matter of common knowledge to those nearly concerned that some type-setters are able to set type at almost twice the rate of others. This greater rapidity is not due, as might be thought, to greater deftness with the fingers, but to the ability to hold in the memory a relatively large number of the words that are to be set up. It would be easy to devise psychological tests that would enable us to know when a boy possessed this capacity in a high degree and when he did

not. It need hardly be said, however, that no attempt has been made in the past to make use of such tests when accepting apprentices for type-setting. The examinations to which prospective type-setting apprentices have been subjected were not such as would indicate those boys who would become rapid workers.[49] This statement may be generalised so as to apply to apprentices in all trades.

Beginning, then, with a Vocational Laboratory, the primary aim of which was to advise *apprentices* when choosing vocations, the function of this laboratory might be extended until it dealt with *all* young persons about to start work. Such an establishment would be in keeping with a wide-spread and growing tendency.[50]

[49] *Cf.* H. Emerson, *The Twelve Principles of Efficiency* (p. 156): "The type for the great newspaper is set up by linotype operators. Apprenticeship is rigorously limited. Some operators can never get beyond the 2,500 em class, others with no more personal effort can set 5,000 ems. Do the employers test out applicants for apprenticeship so as to be sure to secure boys who will develop into the 5,000 em class? They do not; they select applicants for any near reason except the fundamental important one of innate fitness."

[50] It is interesting to note that some years ago Mr. Cyril Burt was appointed Psychologist to the Education Department of the London County Council. His excellent memoranda entitled *The Distribution and Relations of Educational Abilities* (1916) are a valuable contribution to the sort of scheme outlined above.

Lecture IV.

THE BEST METHOD OF WORK

> **"We can see our forests vanishing, our water-powers going to waste, our soil being carried by floods into the sea; and the end of our coal and our iron is in sight. . . .**
>
> **"We can see and feel the waste of material things. Awkward, inefficient, or ill-directed movements of men, however, leave nothing visible or tangible behind them. Their appreciation calls for an act of memory, an effort of the imagination."—Frederick W. Taylor (*The Principles of Scientific Management*, pp. 5-6).**

§ 1

Scientific Management, Taylorism, and Industrial Psychology

I INTEND to devote the greater part of this lecture to describing certain new methods of work, which have been elaborated with the idea of eliminating wasteful expenditure of human energy from certain industrial processes, and have been put into actual operation.

I use the term "method of work" here in a fairly wide sense. Modifications of tools, and adaptation of mechanical apparatus to the psychophysical constitution of the operatives, are

included in its meaning. I shall understand by the term primarily, however, the arrangement of mental and physical processes involved in the performance of particular kinds of labour.

The new methods which I propose to describe have been constructed in association with the American system known generally either as *Scientific Management* or as *Taylorism*. As this course of lectures is concerned with *Industrial Psychology*, it is necessary to define the relations between Industrial Psychology and this system.

As I said in my last lecture, scientific management was originated in America by Mr. Frederick W. Taylor.[51] His first experiments were made apparently about 1882. Their beginnings were not very successful, and even after success had been attained, it was some time before a knowledge of what had been done became general. Taylor's results were so remarkable, however,—indeed, almost so incredible,—that, when they did become known, enterprising and sharp-eyed employers everywhere began to introduce into their establishments a variety of features more or less like those characteristic of Taylor's methods. Throughout the whole of his work, Taylor emphasised the scientific attitude, with the result that his system came to be considered

[51] See his *The Principles of Scientific Management* (1913). Also, *Cf.* R. F. Hoxie's *Scientific Management and Labour* (*passim*), 1915.

essentially a system of workshop *management* on *scientific* principles. Hence the name *scientific management.* This being so, it is easy to understand that when the system was introduced into numerous industrial plants it should often be termed Taylorism; even if, as often happened, the system adopted in a given workshop bore a very small likeness to Taylor's own system, and shewed little application of anything that could be called science.

Considering the origin of the system, it seems to me broadly correct to equate the two terms *Scientific Management* and *Taylorism*, although this hardly does justice to other efficiency engineers besides Taylor who have made important contributions to it. It must be borne in mind that a system may now appropriately be called *scientific management* and yet not possess all the features of the system devised by Taylor. Time has shewn that the original Taylor system is in some conditions susceptible of useful modifications.

In practice in the United States, "scientific management" takes different forms. It is generally assumed that there are several "standard" systems in addition to Taylor's; for instance, those of Gantt [52] and Emerson,[52] and certainly these men emphasise different parts of the

[52] *Cf.* H. L. Gantt's *Work, Wages, and Profits* (1912), and H. Emerson's *The Twelve Principles of Scientific Management;* also, R. F. Hoxie's *Scientific Management and Labour* (pp. 65-75 and 140-168), and N. C. Harris' *Industrial Efficiency* (*passim*).

system. A thorough investigation by a Federal Royal Commission proved that in no establishment as a whole had *all* of the features of *any* standard system been introduced, but that individual employers universally modified the system adopted by them in accord with special ends and conditions. Thus, although there were only two or three forms of wage payment associated with the standard systems, it was claimed that as many as twenty-five forms were found in practice in "scientific management" establishments.

When we come to "systems" not standardised, however, the situation is almost chaotic. System "fakers" are innumerable; and their "inventions,"—generally bad arrangements of some of the more superficial characteristics of scientific management as understood by Taylor, —are often modified by individual employers to suit their own purposes, and present an appearance which suggests neither management nor science. Any introduction of scientific management needs to be supervised by a man with a scientific training; indeed, part of labour's hostility to the system has been the outcome of the cavalier opinion of many employers that anyone was good enough for that purpose. No matter how good a system is, it may yield deplorable results in incompetent hands; and scientific management is hardly worth considering except in so far as it is animated and controlled by the spirit of science.

Let us proceed, however, to the important question: what are the essentials of scientific management in theory? By saying "in theory," I do not mean to imply that it is impossible to carry these essentials into practice: what I wish to emphasise is the difference between the "systems" which in practice are frequently termed systems of scientific management, and such systems as should alone be called by this name if we speak precisely.

Gilbreth defines scientific management as management based upon measurement (*Applied Motion Study*, *et passim*). While this is no doubt true, it hardly suggests the vast difference between *scientific* and the *old* type of management. In order that this difference may be realised, it seems best to describe the new management, as Taylor himself does, by contrasting it with the old. This old type of manage ment Taylor calls, in its best form, the management of *initiative and incentive*.[53] He arrives at this definition by observing, first, that under the old system trade knowledge and skill were in the possession of the workmen, who had acquired them personally from older workmen with whom they had happened to be in contact when beginning their industrial life. The ablest of the old managers, he claims, clearly recognised that the body of workmen possessed far more

[53] *The Principles of Scientific Management* (p. 34, *et passim*).

trade skill and knowledge than he. His policy in consequence was to create a situation in which the workman's skill and knowledge would be most willingly applied. In a word, the old managerial aim, in Taylor's phraseology, was to find an *incentive* which would obtain as its response the *initiative* of a body of men possessing a vast trade knowledge and skill. This was the management of *initiative and incentive* at its best. What it was at its worst is common knowledge.

The first step from this position towards *scientific* management was the perception of the fact that the trade knowledge and skill of any *particular* workman, no matter how good he might be, were faulty, and altogether incomparable with that possessed by the entire body of workmen. The second step was the perception of the fact that it was possible to collate and sift the whole of any trade skill and knowledge, and from the results to construct standards which might be deliberately taught the workman instead of his being allowed to gather his skill and knowledge from the opportunities which chance placed in his way. The final step consisted in the perception of the fact that scientific study of trade processes would yield fuller and more accurate knowledge than was possessed even by the whole body of workmen. Hence, in the fully developed idea of scientific management, the management should possess the greatest trade knowledge which it is possible

to obtain, and should teach this to the employee as he requires it. The problem of incentives still remains; but it is now a problem of inducing the workman, not to act on his own initiative in applying traditional knowledge, but to accept new methods of work and working conditions that are much more efficient than the old.

An illustration may make the difference between the two systems clearer. The author recently visited a large printing establishment where scientific management was in practice. The superintendent of the planning department,—which is at the heart of scientific management,—showed him copy for a page of advertisements for a magazine. A number of differently-sized and differently-shaped advertisements had to be arranged on the one page. Under the system of *initiative and incentive*, the arrangement of the advertisements on the page would have been left to the judgment of the compositor, who would have decided what type to use for headings, sub-headings, etc. Here, however, this was decided by the planning department. The compositor received the advertisements along with an instruction card which told him precisely how the page should be set up. The function of *judgment* and the function of *execution* had been specialised and were now exercised by different workmen.

In accord with this general outline, we may

say that scientific management is presented with three main tasks. These are :

(1) *To determine* scientifically the best possible conditions of work ;

(2) *To induce* workmen to accept the conditions of work that have been proved scientifically to be best ;

(3) *To teach* workmen the new *work methods* devised as part of the best possible work conditions.

These three tasks must now be briefly discussed.

(1) *The Scientific Determination of The Best Possible Conditions of Work.*

I use the term " conditions of work " in a very general sense, and include under it two sorts of facts, which are (*a*) the characteristics of a workman's immediate environment, and (*b*) the characteristics of the actual processes of labour performed by a workman when engaged upon any task.

(*a*) Scientific management has given much attention to the immediate environment of the workman. Its efforts here may be analysed in various ways, but I shall state merely their general aim. Attempts have been made, for instance, to ventilate workshops in accord with the laws of hygiene. One interesting fact lately brought to light in this connection is that

humidity and *temperature* seem to have a greater effect in producing discomfort than the presence of "impure" air.[54] Attempts have also been made to modify lighting, and to remove shining surfaces. A certain firm increased the output of its evening workers ten per cent., simply by changing its system of lighting. There is evidence that bright lights and shining surfaces often have a detrimental effect upon workmen. Again, there is a strong feeling at the present time that chairs should be provided for all employees when working. This is a somewhat revolutionary idea: yet the results of putting it into practice have been considerable. In the future, the shopwalker who is careful to prevent any countergirl from sitting or lounging when not serving a customer or otherwise employed, will be considered ignorant of his business.[55] One efficiency expert recently advocated the provision of a chair for *every* employee in any establishment, the chair to be adjusted so that, if desired, work could be carried on while the worker was seated.[56] Special rest chairs and lounges were also advocated for those engaged in very

[54] See C. K. Ogden's *Industrial Fatigue* (*Nineteenth Century*, Feb., 1917, pp. 425-426). Other interesting relevant matter,—chiefly concerned with fatigue,—will be found in *The Engineer* for Sept. 29th, and Oct. 6th, 1916.

[55] Why should every shop salesman or saleswoman not be provided with a movable "chair" consisting of a stout rod of iron, inserted vertically into a hole in the floor, and surmounted by an appropriately-shaped piece of wood for a seat? This could be put out of the way in busy periods.

[56] See F. B. and L. M. Gilbreth's *Fatigue Study* (1916).

tiring work, to be used either in pauses throughout the morning and afternoon spells, or in the lunch hour.

Some of the most striking of the environmental changes introduced by scientific management have been concerned with the grouping of men and machines, and the organisation of all the departments of any industrial plant into one whole. By these means, much waste has often been prevented. While, in a system of scientific management well carried out, there should be appropriate pauses for workmen, no workman should ever need to be idle for temporary want of materials or tools. Industrial establishments in which idleness for such reasons is sometimes necessary are not uncommon. The fault lies with the management; and operatives often feel such enforced idleness irksome, especially if it occurs during the early part of the day and when they are on piece work. Where scientific management is carefully and thoroughly applied, however, all parts and processes in a plant are co-ordinated by the management; and the whole establishment works together like one huge machine,—indeed, almost like a living organism.[57]

(*b*) Ways in which scientific management has modified actual processes of labour will be illustrated in some fullness in the next section, and

[57] *Cf.* Josephine Goldmark's *Fatigue and Efficiency* (pp. 201-203).

the detailed study of physical movements involved in labour will be discussed in the third section. All that need be said here, therefore, is this. The actual processes of labour that come within the purview of scientific management are not only physical movements. Mental processes, such as decisions and attention, must also be studied. Scientific management has to construct the most efficient *arrangement* of the *necessary* elements of any given work. It must itself determine what the necessary elements are. As a result of its investigations into any industrial task, there should emerge the best methods of performing that task. It should be noted in particular that selection of workers on the basis of natural fitness finds its place in the system of scientific management just here ; for engaging and placing workmen on this principle is a most efficient work method for the employing department.

(2) *The Problem of Incentives.* This problem is largely psychological, since the important factors involved are motives and attitudes of will. All that it is possible to do here is to state briefly the scientific management position with regard to it.

Apart from any other reason, there is a universal conservatism in men which tends to make them hostile to any change that concerns them, especially when the utility of that change is not obvious. Men who have worked ten, twenty,

or thirty years by one method do not take kindly to another, particularly if the new method be difficult to learn and include elements, such as pauses of definite length, which are wholly unintelligible to them. Scientific management therefore offers workmen an increase in wages, partly as a reward for greater output obtained with their co-operation from new conditions, partly as an inducement to accept these conditions. The wage increase is generally considerable,—from 25 per cent. to 100 per cent. of the former wage,—this being given if new conditions are accepted and set tasks accomplished. Taylor himself used a differential piece rate. A low basic piece rate is used until output reaches a certain point; if this point is reached by the workman, this basic piece rate is automatically increased and applies retrospectively. The systems of Gantt and Emerson differ from that of Taylor chiefly in their methods of wage payment. Gantt's method of payment, for instance, is time work with a bonus if given tasks are completed in given times. Practically, this is equivalent to a differential piece rate.

An essential part of the scientific management solution of the problem of incentives is the method of *task work.* Task work is so essential to scientific management, especially as conceived by Taylor, that we find in the literature on the subject *task management* used

as equivalent to *scientific management.*[58] What, then, is task work ?

Task work consists of the setting of definite amounts of any given kind of work for given times. The amount set for a given time is determined by scientific experiments, and then becomes a standard ; and any workman who attains this standard receives a bonus, premium, or higher piece rate. A cabinet-maker receives £1 for making a certain table ; but he must make it in, say, thirteen hours. If, however, he makes it in standard time, he receives 25s. or more.[59]

Taylor's chief advocacy of task work is based upon the psychological fact that everyone prefers a definite to an indefinite task. The schoolboy, he says, works much better when set a definite number of lines to learn than when instructed to learn simply as much as he can. It seems true generally that people like to know

[58] Taylor himself uses the phrase " scientific or task management " (*The Principles of Scientific Management*, pp. 26, 30. *Cf.* also pp. 35, 39, and 120-122).

[59] If he occupies *more* time than that allowed, trouble may arise. In a certain case (in Scotland) a man had a complaint laid against him by his foreman because, when working on a job which was timed to take slightly over a fortnight, he took a quarter of an hour more than the time that was fixed for the job.

It is thus clear that if the system of task work be in operation, reasonable working conditions are possible only if times are set *fairly*. In systems of scientific management (properly applied) tasks *would* be reasonable, because they would be based upon scientific calculations ; but it is easy to see that impossible tasks might be set. The fact that scientific management has generally adopted task work means that it can be readily converted into a system of speeding up.

just how much they must do in a given time, even if the amount is large. The knowledge eliminates, for instance, the necessity of deciding at any time whether to do a little more or not. It eliminates a certain amount of worry. Taylor claims that the setting of reasonable tasks has an important effect upon the motives of the workman, and upon the pleasure he derives from his work.

Before leaving the question of incentives, it should be noted that the answer to it is not to be found in any system of wages, in the narrow sense of the term. The problem is much wider than this, and becomes ever wider with labour's acceptance of certain economic theories and policies. There is a large social factor involved. And perhaps chiefly there is involved the question of *security*, as distinct from temporary high wages.

(3) *The Educational Problem.*—When the workman has consented to accept scientific management, the educational problem becomes the most important (assuming that the best conditions of work have already been scientifically determined), and particularly the actual teaching of the new methods of work. For the carrying out of this task, scientific management employs *functional foremen.*[60]

[60] See F. W. Taylor (*The Principles of Scientific Management* pp. 122-126); and F. B. and L. M. Gilbreth (*Applied Motion Study*, pp. 21-34).

In Taylor's system there are eight functional foremen, or functional departments acting through foremen, who come into contact with any one workman. The functions represented by these men readily come together into two groups, which may be called respectively the *Planning Department* and the *Performing Department*.

The *Planning Department* consists of the functions of the *Instruction Card Clerk*, the *Route Clerk*, the *Time and Cost Clerk*, and the *Disciplinarian*. The *Instruction Card Clerk* (or the sub-department representing his function,—and similarly in the other cases) must elaborate, on the basis of the results of scientific experiment and precise measurement, an instruction card for each job. This informs the workman just how his job is to be carried out,—what tools must be used, the speed of his machine, and the time for the whole job and its parts.—The *Route Clerk* determines the route of any article through the shop from its stage of raw material to that of finished product. He decides, on the basis of his scientifically obtained data, where in its career through the shop it is to be at any given movement: that is, what workmen and what machines are to deal with it at given times. He must also consider the location of the machines so that the route may be direct and unnecessary zig-zag paths avoided.—The *Time and Cost Clerk* records the actual times taken by workmen

for their jobs, and from these constructs the pay roll, and calculates bonuses.—The *Disciplinarian's* task seems to differ in different systems, and may, possibly, be dispensed with altogether. It is generally assumed that the disciplinarian should act as a kind of arbitrator, especially between the workmen and the *performing* department; but his function is sometimes supposed to include the engaging and placing of employees as well. It would seem that the foreman whom Taylor named the Shop Disciplinarian is becoming in scientific management concerns *The Employing Department*, which exercises the functions of arbitration and the placing of employees according to mental and physical aptitudes.

The *Performing Department* consists of the functions of the *Gang Boss*, the *Speed Boss*, the *Repair Boss*, and the *Inspector*. Men representing these functions are in direct touch with the workmen. The *Gang Boss* must instruct the workman as to the precise method of doing his job: he must *show* him how the directions on his instruction card are to be carried out,—how, for instance, a job can be done in the time allowed for it. He must also see that the *Route Clerk's* directions are followed.—The *Speed Boss* has charge of the speed of the *machines*. He must show the workman that the speeds indicated on the instruction card are the best,—that machine speed must be adapted to the job, and the like. His name is an unfortunate

one,[61] since he has nothing to do with speeding up the men: *standard times* are determined by the *Instruction Card Clerk.*—The *Repair Boss's* function is clear from his name: he must look after the running of the machines, prevent such delays as those due to faulty belting, and generally show the workman how to keep his machine in good order.—The *Inspector* has charge of the *quality* of work. He must teach the workman how to bring his work up to the necessary standard of excellence. He does not, for instance, merely condemn an article as below standard quality: he finds the workman who turned it out, and teaches him how to improve its quality. His function is a highly important one. No job is entered upon an employee's pay roll until it has passed the *Inspector*.

It will be seen that by means of this specialisation of functions, the teaching necessary under scientific management is possible. The foremen, of course, must be competent; but granting this, the individual workman has the help of a number of different men who have each specialised upon one feature of his work. It is claimed that the method by which the foremen are paid for good work,—a bonus for every man under them who does his job in standard time,

[61] It may be said from the employer's point of view: Why not choose a "better" name? The answer is, briefly, that the giving of names in cases such as this is not altogether a matter for the employer. The author is acquainted with one case in which functional foremen were all given the colourless title of subforemen by the employer; but the men called them submarines.

and a higher bonus if all their men make their tests,—rapidly transforms them from drivers to teachers.[62]

I shall now indicate briefly and in a very general way what is *the relation between Scientific Management and Industrial Psychology.* From the definition of Industrial Psychology given in the first lecture and the immediately preceding exposition of Scientific Management, this relation will be broadly clear. Industrial Psychology, we may say, touches Scientific Management at many points and *must* be used by it if it is to apply *all available relevant* science. It would appear that some "efficiency engineers" deny this, partly through ignorance of psychology, and partly through a very clear recognition of what can be done simply by the application of physical and mechanical science and by common sense. Nevertheless, we can see that psychology is relevant to scientific management methods in numerous ways, chiefly, of course, in selection of workers (including foremen), but also in connection with the problem of incentives, and the

[62] Whether or not management in the future will retain Taylor's eight functional foremen (or departments) is a difficult question. It is claimed by some who are in close touch with the British workman that he will not tolerate eight bosses. To adapt the system to British conditions, therefore, it is urged that the workman be allowed to remain in contact with one foreman only, and that this foreman be taught by the various functional departments. Various modifications of the original scheme are obviously possible. See an article entitled *Taylor's Principles in Modern British Management*' in a volume called *Lectures in Industrial Management* (Pitman, 1919).

problem of constructing the best methods of work.

It is of some interest, finally, to note the "constants" temporarily assumed when the attempt is made, on the one hand, to select workers on the basis of natural fitness, and on the other hand, to construct good working methods. In the first instance, we temporarily regard the conditions of work as fixed, as a "constant," and seek for those human organisms most adapted by nature to these conditions. In the second instance, we temporarily regard the nature of the man as fixed, as a "constant," and attempt to adjust conditions of work to his peculiarities. In practice, both points of view may be combined. In any given case, it may seem more easy to carry out selection of workers or to devise new methods; and it will, in all probability, often appear possible to do both. It is perhaps impossible to predict on which side the greater adjustment may be made; but the proximate aim of scientific management is to obtain the greatest possible adjustment, and in this attempt industrial psychology becomes relevant to it.

I proceed now to give illustrations of certain new methods. In doing so, I shall endeavour to make clear the chief principle involved in each case. As a rule, the methods to be described *each* exhibit *several* qualities of ideal working methods; but I shall in any case emphasise that quality which the method, as used, exhibits most conspicuously.

§ 2

New Methods of Work

(1) I shall begin with accounts of several cases in which the new methods elaborated and put into practice illustrate very clearly *the principle of pauses.* It may be remembered that, in discussing the Ergographic results, I pointed out that we should be cautious in formulating our expectations as to what might be gained by interspersing a day's work with appropriate rest periods. Such facts as those about to be presented, however, confirm the deductions which it seemed reasonable to draw from those results.[63]

(*a*) The first of the cases to be given is one of the earliest scientific management achievements, and is now, no doubt, known to many of you. I refer to F. W. Taylor's results with the pig-iron handlers at the Bethlehem Steel Works, U.S.A.[64] Taylor's management work began at the plant of the Midvale Steel Co. of Philadelphia, about 1880.

The facts now to be described occurred at Bethlehem about 1900.

[63] See above, pp. 86-88.

[64] See F. W. Taylor's *The Principles of Scientific Management* (pp. 41-64). This case is summarised by Josephine Goldmark (*Fatigue and Efficiency*, pp. 195-199); by H. Münsterberg (*Psychology and Industrial Efficiency*, pp. 216-217); by H. B. Drury (*Scientific Management*); and by others.

A line of rail for trucks ran into a field alongside huge piles of pig-iron. An inclined plank was placed with one end on the ground and the other on the side of a truck, and the pig-iron handler was required to carry a load of iron up this plank and to tip it into the truck. Seventy-five men were employed in this work, and the average amount of pig-iron shifted per man per day was 12½ tons. It was found, however, that some men could shift much more than this quantity. Pig-iron was, at that time, not a very valuable commodity, and hence the management turned its attention to every possible method of decreasing the cost of treating it. As a result of certain calculations made from this point of view, it seemed that a good pig-iron handler should shift much more than 12½ tons per day. Great difficulty was experienced, however, in attempting to discover just how much pig-iron a man should shift in a given time. Laborious calculations were made, movements were carefully studied, with at first no definite result. The failure was due to the fact that the men were assumed to be "doing work" only when moving a given weight of metal from one point of space to another, and the calculations had taken into account only the actual weight of pig-iron shifted from the pile to the truck. The time taken by a man to carry a weight had been neglected, and he had not been considered as "doing work" so long as he stood motionless with a load upon his shoulders. As soon as this great mistake

was realised, the law sought for was obtained. "Throughout the time that the man is under a heavy load," says Taylor, "the tissues of his arm muscles are in process of degeneration, and frequent periods of rest are required in order that the blood may have a chance to restore these tissues to their normal condition."[65] That is to say, a pig-iron handler is expending energy almost as much when he stands motionless with his load upon his shoulders as when he walks with it. The law sought for by Taylor could thus be formulated, and was as follows: a man must be *under load* a definite percentage only of the working day. The important fact was the quantity of human energy expended, and not, as was thought, the *output* from this expenditure. The problem was to realise just when human energy was being expended, and then to utilise it in the best possible way.

It thus appeared to Taylor that a given expenditure of energy demanded a certain amount of rest for recovery, and that this rest should not be calculated from the actual weight of metal shifted from the pile to the truck, but only from this weight plus the time occupied by the man while under load. As a result, he first broke the working day into a series of work spells followed by pauses. He calculated that when whole pigs are being handled, each weighing

[65] F. W. Taylor's *The Principles of Scientific Management* (p. 58).

92 lbs., a good handler can be under load only 43[66] per cent. of the *working day* (which was ten hours). During the remaining 57 per cent. of the working day, he must be entirely free from load, for the purpose of recovering from fatigue. As the load grows lighter, the percentage of the day during which a good workman can be under load becomes greater. Thus, if half pigs are being handled, each weighing 46 lbs., a good workman requires to rest for only 42 per cent. of the working day, and can be under load without detriment to himself during the remaining 58 per cent.

It was not sufficient, however, to know only so much. If, when handling whole pigs, for instance, a workman were allowed to keep working until practically exhausted, he would not be able to be under load 43 per cent. of the working day. He would soon grow fatigued, and have to cease work altogether. The question, therefore, was to arrange a series of pauses interspersed throughout the day. The precise series used was decided upon as the result of experiment.

"Practically," says Taylor, "the men were made to take a rest, generally by sitting down, after loading ten to twenty pigs."[67] If we suppose that the rest was taken after every 20 pigs, the durations of the work and rest intervals

[66] In the note to p. 61 of *The Principles* Taylor takes this figure as 42. In the text (p. 57) it is stated to be 43.

[67] *The Principles of Scientific Management*, p. 61 (*note*).

were roughly 9 minutes and $1\frac{1}{2}$ minutes respectively. The 9 minutes' work, however, was not 9 minutes under load, but only half of that time, since one half of it was occupied in returning from the trucks empty-handed. As Taylor says, during the return the men's muscles had "opportunity for recuperation." If we suppose that the rest was taken after every 10 pigs, the durations of the work and rest intervals were roughly $4\frac{1}{2}$ minutes and $\frac{3}{4}$ of a minute respectively; and here only $2\frac{1}{4}$ minutes were spent under load.

So much for the pauses. The men were not allowed to carry their loads in any way they pleased. They were instructed, on the contrary, just how to raise them from the ground, for instance, and just how fast they were to walk with them, and so on. And, of course, they were told just when they should rest.

Further still, it was found that not all men were suitable for this kind of work. The best fitted man seemed to be one who was physically strong and relatively unintelligent. Of the original gang of pig-iron handlers only about one in eight satisfied these requirements. Accordingly, the others were moved from this to other work connected with the plant. In the end, Taylor had a gang of pig-iron handlers who were selected men, and who worked according to the method he had constructed. It was necessary to teach these men the new method very carefully. Of the first man to be taught

it, Taylor writes: "Schmidt started to work, and all day long, and at regular intervals, was told by the man who stood over him with a watch, 'Now walk—now rest,' etc. He worked when he was told to work, and rested when he was told to rest."[68] And he adds a little later: "If Schmidt had been allowed to attack the pile of pig-iron without the guidance of a man who understood the art, or science, of handling pig-iron, in his desire to earn high wages he would probably have tired himself out by 11 or 12 o'clock in the day. He would have kept so steadily at work that his muscles would not have had the proper periods of rest absolutely needed for recuperation, and he would have been completely exhausted early in the day. By having a man, however, who understood this law, stand over him and direct his work, day after day, until he acquired the habit of resting at proper intervals, he was able to work at an even gait all day long, without unduly tiring himself."[69]

In this new method, then, a chief point was the series of pauses. There was also selection of workmen, and some modification of actual movement. What were the results?

Under the old system, in which methods of work were left to the pleasure of the individuals, the average quantity of pig-iron shifted per man per day was $12\frac{1}{2}$ tons; under the new system, in which the men were under load only about $4\frac{1}{3}$

[68] *Ibid.* p. 47. [69] *Ibid.* p. 59.

hours (when handling whole pigs) they averaged 47½ tons per man per day. That is to say, output was almost quadrupled. We can well believe Taylor's statement that managers of similar establishments at first refused to believe this, saying that, by offering high wages, a *maximum* of 25 tons per man per day might be shifted. That is, they thought it *possible* to double output by ordinary speeding-up methods; they would scarcely believe that output could be quadrupled. Yet the result obtained, it must be emphasised,—for this point is of supreme importance,—involved no *greater fatigue* than the old result; in fact, it probably involved less, for the fatigue products were continually carried off, as they accumulated, during the rest pauses throughout the day. Of Schmidt, Taylor says, that "at half-past five in the afternoon (of the first day) he had his 47½ tons loaded on the car. And he practically never failed to work at this pace and do the task that was set him during the three years that the writer was at Bethlehem."[70] This is sufficient reply to the possible objection that the new method must have involved over-exertion. No man who constantly over-exerted himself could continue at work of such character as pig-iron handling for a period at all approaching three years. It should be added that the wages of the men were increased about 60 per cent.

[70] *Ibid.* p. 47.

It is perhaps worth while adding here that from the point of view of ideal methods, the handling of pig-iron by individual men is bad. Why should human bodies be required to bear weights which can very easily, and at less cost, be borne by machinery ?

This will be appreciated by anyone who has seen iron shifted with an electro-magnetic crane.

(*b*) The case now to be given illustrates *the principle of pauses* perhaps even more clearly than that of the pig-iron handlers. In this instance, the operatives did not appear to be suffering from undue fatigue under the existing method ; and the primary object of the introduction of pauses was not to decrease this factor,—although this was probably one of its results,—but to increase output. The occupation was very different from that of the handlers of pig-iron, which involved work essentially heavy in its nature. This was *light* work, namely, folding handkerchiefs ; [71] and it is interesting to see that the principle of pauses was as relevant here as in the case of the heavy lifting. In the present instance the operatives were girls.

Before the re-arrangement of their work by the management expert, these young women had worked through the day with no fixed pause but that for lunch at noon, though there might

[71] This case is given by F. B. and L. M. Gilbreth (*Fatigue Study*, pp. 127-131).

be occasional breaks in order to go for fresh material or to take back the folded and counted handkerchiefs. The work was paid for at piece rates, so that other intervals for rest, in addition to the lunch period, might be taken if the girls wished ; but this did not happen often. During the folding of the handkerchiefs, the girls sat upon chairs of ordinary size and height, the table on which the handkerchiefs were placed being somewhat lower than ordinary tables.

Careful studies were made of this work, and as a result the following method was recommended and successfully adopted. The table on which the work was done was raised to a height which promised a minimum of effort in reaching to and fro. On this table the handkerchiefs were kept in three heaps, those not yet folded, those which were being handled, and those duly checked and parcelled (with which the operative had finished). The most interesting of the alterations concerned the periods of work. Every hour was considered as divided into ten six-minute periods. In any hour, the operative remained sitting for the first four such periods, that is, for 24 minutes. During this time she worked five minutes and rested one minute ; and so on for the 24 minutes. Thus four minutes out of these twenty-four would be spent resting ; and these rests were taken sitting before the work-table. For the next twelve minutes the girl stood to do her work, observing the same routine of work and pause as before,

that is, working five minutes and resting one, and again working five minutes and resting one. During the next three periods of the hour (that is, the next 18 minutes) she might sit or stand as she chose, but continued the plan of working five minutes and resting one. For the tenth or last six-minute period of each hour, the girl did no work at all, but might stand, sit, walk about, go out of the work-room, do just what she pleased. The only exceptions to this six-minute complete rest from work were in the two hours preceding lunch and preceding the end of the day's work respectively. At those two times the last six minutes of the hour were given to work. The success of this careful arrangement of work and pauses was shewn when the output became and remained *three times as great as it had been before the reorganisation.* No more strain or fatigue [72] was imposed on the girls by the new method. They asserted, indeed that they were less tired under the new scheme than under the old, although the work accomplished was three times as great as formerly. More interest, too, seemed to be aroused in the work, the alternation of activity and pause lessening the monotony of the occupation.

(*c*) I shall conclude my account of illustra-

[72] All statements of this kind must be accepted with the greatest caution, *as we have at present simply no accurate test of fatigue whatever*. *Cf*. J. Ioteyko (*The Science of Labour and its Organisation*, pp. 77-80).

tions of the principle of pauses [73] by describing very briefly two recent cases.

The first concerns trench-digging. Two companies who were engaged on this work decided on a competition. The men of one company adopted the method of working continuously until rest was imperative. Those of the other company, however, were divided into three sets, each of which worked five minutes and then rested ten. The result was that this latter company won an easy victory. The second case occurred in a foundry engaged on munitions work.[74] Here the management insisted on the moulders resting 15 minutes in each hour. As the men were on piece rates, they at first objected strongly to a method which they considered would lower their wages. It was soon found, however, that the pause method had made possible an increase in output.

(2) I shall next give an account of a new method which illustrates another principle, namely, *the principle of substituting automatisms for frequent acts of decision.* It concerned the putting together,—in technical language, the *assembling*,—of the base group of a braiding

[73] It should be mentioned that pauses were introduced into the work of the girls in the bicycle-ball factory (see Lecture III.). Four ten-minute rests were distributed through the day. See F. W. Taylor (*The Principles of Scientific Management*, pp. 92, 95-96).

[74] *Industrial Fatigue and its Causes* (p. 11. Cd. 8213).

machine, a standard product of the New England Butt Co.[75]

Before the management expert re-arranged this work, it was done as follows. The various parts of the braider base were kept in small boxes, or simply on the floor near to the assembler, who worked at a low bench. These parts he picked up as he wished to use them; and he would put the braider base together in any order which tradition or his own experience had taught him.

A detailed study was made of the problem of the best method of assembling, in the course of which it soon became clear that there were two problems involved. The first concerned the size of the bench or table on which the parts were to be assembled. This, it seemed, must be arranged to hold most suitably all the tools required and the machine as it gradually grew larger. The second problem concerned the provision of the most convenient temporary resting-place for the tools and parts, before they were required in the order of the work.

Three conditions seemed necessary for the solving of these two problems. Firstly, the distance for carrying the hands when "loaded" had to be shortened as much as possible. Secondly, the parts of the braider must be

[75] See F. B. and L. M. Gilbreth's *Fatigue Study* (1916, pp. 132-141).

arranged in the sequence in which they could best be fitted to the base. Thirdly, each tool and each part must be placed so that it could be taken up, moved to the bench, and used, as easily as possible. From a consideration of these conditions came the idea that the various parts of the machine should be placed upon a holder or "packet,"[76] and the base of the braider upon a table as near this holder as possible.

The holder consisted of a low table with a vertical panel rising above one edge. In this upright panel were placed removable wire pegs for supporting, in the best position for being grasped, the various pieces of mechanism to be used. The packet also held different kinds of forked hooks, hangers, removable platforms, shelves and upright supports, for holding the various pieces of the machine.

The time and labour of the assembler were economised by having all the parts of the braider base placed, in definite sequence, upon the holder by an unskilled labourer or boy, the skilled assembler using his movements exclusively for the actual putting together of the parts. In placing the various pieces on the holder, the exact sequence in which they were to be affixed to the braider was observed. This eliminated hesitation or indecision regarding order in the

[76] A number of photographs of this "packet" are given in F. B. and L. M. Gilbreth's *Fatigue Study*.

grasping and affixing of different parts. The various factors of the assembling were soon standardised throughout. The parts of the machine and all tools required were always in precisely the same positions, so that the assembler proceeded always uninterruptedly and in a definite order.

In the result, the difference between the old and new methods was very great. Before the re-arrangement of work and method, it was considered a good day's work for one man to put together 18 braider base groups. By this new method, each man easily assembled 66. And this larger output, it is claimed, involved no greater fatigue [77] than the smaller.

This case is instructive and suggestive in numerous ways; but the chief point to be emphasised is that the new method, as compared with the old, eliminated the necessity for numerous acts of decision. In dealing with the psychological factors relevant to industry, I pointed out that the making of frequent acts of will involves much fatigue.[78] Now, generally speaking, all assembling of complicated machines by the ordinary methods involves frequent acts of decision. The various parts lie about the worker on a table or floor, and, even if any part is always in the same place, the assembler must constantly decide which part he will affix next. Further, there are, as a rule, no fixed positions

[77] *Cf.* note to p. 181. [78] See above, p. 77.

for tools. The workman picks up a wrench from his right side and drops it almost anywhere. Apart from the mere loss of time involved in such unsystematised procedure, there is in addition a certain worry arising from the necessity of making decisions, and this probably produces fatigue. We may say, generally, that methods of work which substitute *order and habit* for *judgments and decisions*, decrease fatigue, and, in this respect alone, influence output beneficially. The present case is of great interest in view of the specialisation tendency in industry, which renders assembling a more and more common occupation.

(3) The case to be given next is one of the most striking achievements of the scientific study of working methods. *The principle* which the new method here illustrates most conspicuously is perhaps that of *the modification of the actual movements made by the workman.* The new method was that elaborated for bricklaying by Mr. F. B. Gilbreth.[79]

The whole process of laying bricks was studied by Mr. Gilbreth in the most careful and thorough manner conceivable. This study included a careful analysis of the co-ordination between the different workmen engaged in bricklaying,

[79] See F. B. Gilbreth's *Bricklaying System* (chapter on "Motion Study"). The case is quoted by F. W. Taylor (*The Principles of Scientific Management*, pp. 77-85); also by H. Münsterberg (*Psychology and Industrial Efficiency*, pp. 164-165).

and an examination of all the tools used in this occupation. The investigation was perhaps chiefly focussed upon the movements of the man who actually lays the bricks. It was found that 18 separate movements were involved in the accepted method, and an attempt was made to reduce this number.

It soon became obvious that at least some of the movements involved in the accepted method were quite unnecessary and could easily be eliminated. For instance, the pile of bricks to be laid was usually placed at such a distance from the bricklayer that he must take a step from his position at the wall towards the pile for each brick, and another back to the wall when he had got the brick. These steps, it was clear, could be done away with by the simple device of putting the pile of bricks nearer to the man. A similar change was made in the position of the mortar box. A still more obviously unnecessary movement was eliminated also, namely, the bending to the level of the feet for each brick and trowel of mortar. The fact that this movement had been constantly made for centuries seemed to Gilbreth astounding so soon as he had realised that it was altogether unnecessary. For hundreds of years, he exclaims, bricklayers have been content to lower the top part of their bodies, weighing nearly 1 cwt. and a half, a distance of some two feet,—with the necessity, of course, of raising it once more,—every time a brick or a trowel of mortar

was required! The human energy thus wasted must have been, as he suggests, simply enormous.

To obviate the necessity for this lowering and raising of the body, a table was introduced for the carrying of the mortar and the bricks. This table was of such a height that it rendered all stooping for materials unnecessary; and by means of an adjustable scaffold the table was made to rise with the wall and the platform on which the workman stood. Thus, by means of a simple mechanical device, the necessity for lowering and raising a heavy weight some 1,000 times a day,—and the fatigue consequent upon the movements involved,—was done away with.

Again, when a brick was being laid by the old method, the bricklayer generally tapped it with his trowel after he had placed it in position, in order to ensure the correct thickness for the joint of mortar. These tappings seemed to Mr. Gilbreth unnecessary. By experimenting he found that, with a properly tempered mortar, a bricklayer can adjust the thickness of the mortar joint by a slight pressure of the left hand as he lays the brick with it. The elimination of these tappings with the trowel effected a considerable saving of time.

Once more, it was noticed that, by the ordinary method, the workman picked up a brick with the left hand and *then* a trowel of mortar with the right, or *vice versa*. That is, the two movements were performed one after the other.

(These movements involved the innervation of similar muscle groups on the two sides of the body).[80] In the new method it was decided that the workman must pick up the brick with the left hand and *simultaneously* the mortar with the right.

Further still, the bricklayer, when using the old method, had generally to turn a brick over and inspect it in order to set the best facing outwards. This seemed to involve a waste of skilled labour. The arranging of the bricks in such a way that the bricklayer need not carry out this inspection, was therefore handed over to a special man. The bricks were put by him upon the table in such a way that they could be immediately placed in position on the wall, best facing outwards.

By means of such innovations as those described, Gilbreth reduced the number of separate movements involved in the laying of one brick from 18 to 5! This reduction was effected in four ways.[81]

(*a*) Some useless movements were eliminated simply by putting the workman's material nearer to him: such a movement was the step which the bricklayer had to take, on the old method, to get a brick or trowel of mortar.

[80] See above, pp. 88-93.

[81] It has been suggested that the 18 movements included "strike match," "light pipe," and "scratch head."

(*b*) Some movements were made unnecessary by the introduction of simple mechanisms, though without these mechanisms the movements were required: such a movement was the lowering of the body when a brick or a trowel of mortar was wanted.

(*c*) Bricklayers were taught to make certain movements simultaneously which before they had made successively: such movements being the picking up of bricks and mortar.

(*d*) Unskilled workmen were utilised to do certain of the work ordinarily done by the bricklayers: for instance, a special man inspected the bricks and arranged them in such a way that the bricklayer could lay them, best facing outwards, without inspecting them himself.

What were the results? By the new method 30 men were able to do in a given time as much work as about 100 using the old method. Union bricklayers who had been taught the new method averaged 350 bricks per hour per man when working on a factory wall, that is, on "straight" work; whereas by the old method the average per man per hour was 120. In this case, only those who were willing to learn the new method were engaged; those who would not, or could not, were soon dismissed. There was thus *some* selection of workmen here, that is, in so far as only those who would and could learn the new method were given work. These

were paid much higher wages than the usual wages earned by men using the old method.

By the new method of bricklaying, then, output was nearly trebled. Mr. Taylor states, in connection with his account of this method, that, in a certain (non-American) city, a bricklayer's union restricted the number of bricks laid per man *per day* by its members to 275 when working for the city and 375 when working for private persons.[82] This was, of course, under the old method. But the quantities seem out of all proportion to the 350 bricks per man *per hour* laid under the new method on "straight" work. According to Gilbreth, the very much larger output by the new method was obtained at a smaller cost in fatigue.[83]

It may now be said: "This new method was certainly very striking; but much of it seems to be the result of an application of mere common sense. Precisely where does *industrial psychology* enter into it?" In answer, I shall mention two points at which psychology touches the method.

The first is in the substitution of certain simultaneous for certain successive movements. This substitution effected a simple gain of time, no doubt; but, in addition, it probably resulted in a saving of mental energy. Such a saving

[82] *The Principles of Scientific Management* (p. 82).
[83] *Cf.* note to p. 181.

means a decrease of fatigue and of fatigue's undesirable consequences.

The second point at which psychology touches the new method is in the elimination of acts of decision on the part of the bricklayers (with regard to the inspection of bricks for the best facing). Of course, the bricks had to be inspected by someone; but the decision involved in this was largely irrelevant to the special skill of the bricklayer, and was therefore unnecessarily fatiguing to him. By having this inspection done by an unskilled man, the bricklayer's time and energy were being utilised more adequately.

I admit, however, that perhaps the most prominent feature of the new method of bricklaying represents an application of common sense rather than of *any* "science": I refer, of course, to the elimination of unnecessary movements.

(4) I shall now give accounts of two cases illustrating especially *the principle of adjustment of tools to the mental and physical constitution of workers.* The first of these does not illustrate, strictly speaking, an adjustment of *tools:* the adjustment here was in the mechanism with which the operatives were directly in contact. Although such mechanism would not usually be regarded as *a tool* or *tools,* we can nevertheless see that modifications in it are related to workers in the same way as are modifications of the implements ordinarily called

tools. This case may, therefore, be properly given here.[84]

(*a*) The first case is Australasian and concerns apple packing. In my second lecture, I mentioned the experiences of a Tasmanian apple grower with regard to the effect of overtime upon normal output.[85] This gentleman has made numerous experiments with the object of discovering the best methods of doing various kinds of work involved in apple growing. It occurred to him at one stage to make experiments on packing. The packers were girls and were paid piece rates. The process of packing was relatively simple: the girls took the apples one by one from a pile, wrapped each in a piece of tissue paper, and then put it into the case. A good method of work here would clearly be one that utilised an arrangement of the *relative positions* of apples, paper, and case, which would be very convenient for the girl in making the various necessary movements. The tray bearing the pile of apples was therefore placed in a position such that the girl could easily reach it, the tissue-paper was placed in her lap, and the height of the case was adjusted to the height of her seat so that the apples could be placed in the case without the necessity of bending the body. The general aim of the new method was to make the muscle energy expended in packing as small

[84] See above, pp. 26-27.

[85] See above, pp. 66-67.

as possible. It is easy to see at once that here was a fertile field for modifications of methods. Such modifications as were made resulted in a 25 per cent. increase in output.

(*b*) The second case to be considered is concerned with the work of shovelling, and is now fairly well known.[86]

Shovelling is a rather primitive sort of task, and the factors entering into it seem so simple that it might be thought that scientific management could do little with it. The movements made by the shoveller, however, were subjected to analysis in much the same way as the movements of the bricklayers. The investigation was carried out by Taylor at the Bethlehem Steel Works, where about 500 shovellers were employed in a large yard, some two miles in length and half a mile wide. They were required to shovel various kinds of material as occasion arose; sometimes coal, sometimes ashes, sometimes heavy iron ore, and so on. Taylor had not been long in considering the work before he felt that the amount of material shovelled by a good workman in a given time depends largely upon the weight of one shovel full of the material shovelled. Within limits this idea seems obvious as soon as it is grasped. No matter how good a workman a particular

[86] This case is given by F. W. Taylor (*The Principles of Scientific Management*, pp. 64-69): quoted by H. Münsterberg (*Psychology and Industrial Efficiency*, pp. 166-167).

man may be, it is clear that he will not do his maximum at shovelling if the shovel he uses will bear a maximum weight of one pound. On the other hand, it seems hardly less clear that the use of a shovel which would carry a load of half a hundredweight would very quickly tire a workman to the point of exhaustion. The problem thus was to determine the weight of the shovel load which would yield a maximum output. The desideratum was a shovel perfectly adjusted to the physical constitution of the men who should use it.

Taylor therefore induced several good shovellers to perform their work on different materials, now with shovels of one size, now with shovels of another size. He concluded from his investigations that a good shoveller is most efficient, other conditions being reasonable and the workman being allowed appropriate recovery pauses, when he shifts on his shovel an average load of 21 lbs. This highly important conclusion was immediately put into practice. The management gave orders for the construction of shovels of ten different sizes, having their shapes adjusted to the kinds of materials for which they were severally intended. Thus, when ashes were being shovelled, the men used a large flattish shovel which carried an average load *of ashes* of 21 lbs. For shovelling heavy ore, on the other hand, a small shovel was used, the load *of ore* carried by this shovel being 21 lbs. also. Similarly for other kinds of material. Careful

instruction was given the men as to the particular shovel to be used in any case.

Other innovations were also made. For instance, different kinds of bottoms were used when shovelling different kinds of material; the men were instructed to push their shovels into the piles of material to be shovelled, in various new ways; an attempt was made to determine the best distance for a shovel-load of material to be thrown; and so on. In addition to innovations of such kinds, certain pauses were introduced. The most important new feature of the new method, however, was the adjustment of the shovels.

The results [87] were very remarkable. Firstly, the average amount shovelled per man per day was increased from 16 tons to 59 tons. This led to a reduction in the number of shovellers necessary for the work in the yard. It was found that 150 men, using shovels of different sizes and correctly adjusted to the material and their own physical constitutions, were able to do as much as the 500 did originally with one shovel only for all materials. Secondly, the average earnings of the men were 60 per cent. greater after the introduction of the new method than before. Thirdly, after paying for the services of the scientific investigator and for the con-

[87] A very precise form of "task" work was used in connection with the new shovels, so that *part* of the results obtained may have been due to that, and not to the modification of the tools. The general organisation was certainly important.

struction of new shovels, the cost to the management for the shovelling was reduced 50 per cent. Finally, it would seem that the larger output involved no greater fatigue than the smaller. Taylor makes no definite statement on this point; but the inference seems highly probable both from the nature of the new method and from the fact that it was in operation over a long period.

(5) The accounts of new working methods that have now been given are sufficient to indicate the general nature of good methods of work. The results show that the elaboration of good methods, even if difficult, is well worth while. It may be of interest to state here briefly the nature of the results obtained from the use of new methods in a number of further cases.

In a certain cotton plant, new methods increased output 100 per cent.—A young woman engaged, in a cloth finishing department, on the work of folding, completed 887 pieces per day by the use of a new method, whereas by the method previously employed she had completed only 155.—In the manipulating of a drill press, the use of a new method, elaborated as a result of a chronocyclegraph [88] study, effected an increase in output of 100 per cent., no greater fatigue being involved.—New methods in machine shop work increased output from 400 to 1,800 per cent.—An increase of about 200 per

[88] See below, p. 212.

cent. in output resulted from the introduction of new methods into the Watertown Arsenal, U.S.A. Here, in four cases in which the same men had worked at the same jobs under the two systems, the increase in output was 272 per cent.—Finally, according to Taylor, there were, in 1913, at least 50,000 American workmen carrying out their occupations by scientific methods. These men were receiving from 30 to 100 per cent. higher daily wages than others of equal capacity working by traditional methods. At the same time, the companies which had elaborated the new methods had, by their introduction, reduced the cost of production considerably.[89]

It would be a mistake, however, to suppose that attempts to construct good working methods have been universally successful. It is not enough to modify an existing method of work in any way that happens to be suggested; and no new method can hope to meet with success if it leaves out of account important factors. In particular, a new method which adopts merely the superficial features of the methods I have described is likely to meet with failure. To construct a good working method it is necessary to understand *the principles* upon which such a method must be based. The failure in the following case is interesting and suggestive.

[89] See F. W. Taylor (*The Principles of Scientific Management*, p. 28).

The case is given by Mr. John P. Frey (editor of the *International Moulders' Journal*, and one of the three members of the Hoxie Commission [90] on Scientific Management), in an Efficiency Society Bulletin called *Scientific Management and Labour* (pp. 11-12 ; 1916). "Going through one large establishment," says Mr. Frey, "we stopped before a girl who was taking threads previously cut to a certain length, threading these into a needle, and then waxing the thread. The firm's expert informed us that previous to the installation of scientific management each girl had threaded her own needle, cutting off the threads to suit herself.

"The methods of scientific management, however, had shown this to be all wrong, for if a girl cut the threads too short, she had to thread her needle too often, which was a waste of time, while if she cut the thread too long, she lost much time taking the long draws necessary until the thread became shorter.[91] The girls sewing on buttons were, therefore, given different lengths of thread, and a careful record was kept of the number of buttons each girl sewed on per day, and when the length of thread which enabled the girls to sew on the largest number of buttons per day was secured through analysing the results, this length of thread was made the

[90] See below, pp. 231-232.

[91] *Cf.* H. Münsterberg (*Psychology and Industrial Efficiency*, pp. 178-179).

standard. Based on the theory that a girl trained to thread needles could do this more efficiently than anyone else, one girl spent much of her time threading needles with the standard length of thread, this being one sub-division of the trade of sewing on buttons.

However, from a scientific standpoint, this was but a clumsy and slipshod result of an analysis of the sewing-on-of-buttons trade, as we soon discovered, for in another garment-making establishment they had studied this trade with a more searching spirit. If the length of thread with which the needles was threaded determined the number of buttons a girl could sew on in a day, then the length of her arms would also be a factor, for the girl with long arms would take a longer draw after putting the needle through the cloth and the button than the girl with short arms.

Once this scientific fact was discovered the experts made elaborate studies of the problem, girls with short, medium, or long arms, working with standard lengths of thread, being watched and the results of their day's output analysed. As a result of these studies it was possible for the experts to discover the proper length of arm to enable a girl to sew on the largest number of buttons, and the employing department was instructed to supply the button-sewing department with girls whose arms were of the desired length. But even this was not scientifically thoroughgoing, for it was found

that the length of the fingers undoubtedly had an influence, and studies were made to determine what the most efficient length of fingers was, so that the girls in this department who were being specialised as button-sewers would all have fingers and arms of the same length. So in time the firm had a group of girls sewing on buttons, with standardised lengths of thread, with their stadnard fingers and arms.

Here was the perfection of scientific management. . . . But it was not long before the experts, who had studied for many weary days with stop watches and pondered deeply over huge masses of the time studies they had accumulated, discovered that though they had standardised the length of thread and the length of fingers and arms which were to sew on buttons with the thread, there was still a wide difference between the girls' output. . . .

In the end . . . standard lengths of thread, or of fingers, or of arms, were discarded, and each girl was permitted to cut the length of thread to suit herself, with the result that the unstandardised girls were apparently enjoying better health, were less rushed, and were doing better for themselves and their employers than their standardised sisters."

Mr. Frey's explanation of the failure in this case is implied in the following words : "What the efficiency experts had failed to standardise, what as a matter of fact they could not standardise,

were the physical and mental qualities of the workers, their vitality, their ambitions, their nervous co-ordination, their ability to work without physical and nervous and mental deterioration under the monotonous character of the work."

The criticism implied in this statement seems to me largely incorrect both in fact and principle. Of course, such qualities as "vitality," "ambition," and "nervous co-ordination," *have* an important bearing upon a worker's efficiency. Theoretically, however, it would be possible to determine the particular degree of even such general and somewhat vague qualities as these best suited to the work of sewing on buttons.

It might be suggested that the method failed because it did not include a system of regulated *pauses*. Mr. Frey does not refer to any rest periods, and, as he presumably states the new method completely,—he is anxious to give details,—we may assume that there were not any. Now, the more specialised work becomes,—and it is daily becoming more specialised,—the more necessary is it to apply the principle of pauses in methods of work. The reason is perfectly simple. Specialised labour involves the frequent repetition of *the same* physical and mental operations; it thus quickly fatigues the processes involved in it. Rest periods *must* be allowed for recovery from this local fatigue.

But the true explanation seems to be a different

one. Mr. Frey's description suggests that the attempted scientific management in this case was grossly superficial. No good results can be expected from insisting upon unimportant or irrelevant factors, and the question thus arises whether the factors standardised in this case were important. We may say broadly that bodily externals such as were here standardised are *not* indicative of capacity. Thus, you might find two persons with arms and fingers of precisely the same lengths and shapes who possessed nevertheless very different reaction-times. Among the important factors for the work of sewing on buttons would be eyesight, precision of movement, and reaction-time; but, apparently, these were not standardised. Had selection been made on the basis of individual differences in these three functions alone, the results, I venture to say, would have been altogether different. The success of Mr. Thompson's work with the bicycle-ball inspectors depended upon the fact that he realised the vital factor for that work. Had he simply standardised fingers, we would probably never have heard of him.

Mr. Frey's case thus seems to be one in which scientific management was attempted by managers who did not understand its principles, and it shows how failure may result from the application of the superficial features of the system. It suggests the necessity of applying the selection principle to managers as well as to other workers. And the proper reply, therefore, to

Mr. Frey's criticism seems to be this: The failure described was due, not (as he says) to the impossibility of standardising certain features supposed by him to be the important ones, but to the fact that the features actually standardised were largely irrelevant features, much more important features (which could quite well have been standardised) having been neglected.

If, then, a series of pauses, similar to those adopted with the handkerchief folders, had been introduced into the occupation of sewing on buttons, and if the standardised factors had been really important factors, and not, as they were, only distantly relevant to the work,[92] the attempt to apply scientific management here might, quite possibly, have been most successful; and what must now be called a failure might have been used to illustrate the extraordinary results obtained from the application of science to industry.

§ 3

Motion Study

In discussing certain of the attempts that have been made to construct good working methods, I have referred to the study of move-

[92] Probably not all the standardised factors were irrelevant. Thread-length, for example, was probably very relevant.

ments. Motion study, or, as it is generally termed, "time and motion" study, has taken a prominent part in the elaboration of new methods. Some account of its general character will therefore be given here.

We may consider the study of the physical movements involved in labour to be divided into two parts, one dealing with what would ordinarily be called "single" movements, the other with groups or series of single movements.

Study of a single movement is concerned (1) with that movement's *form*, that is, with the path travelled by the moving limb or other member of the body through space; and (2) with the time occupied by the movement. To some extent, the relative amount of time taken by a movement is a test of its relative efficiency. Only *to some extent*, however; a rapid movement might have a detrimental effect upon quality of output, and thus would not be as efficient as a slower one which did not have such an effect. Again, a *very* rapid movement, even if it did not affect quality of output detrimentally, might be unduly fatiguing, and hence not be as efficient as a less rapid movement. Assuming, however, that fatigue and quality of output remain constant, one movement is more efficient than another if it occupies less time.

Now the time occupied by any movement is partly a function of the precise spatial paths which are taken by the elements of it. If I have to move my hand from my right to my left

hip, I can, of course, do this much more rapidly if I move the hand horizontally than if I move it from the one hip to the other by way of the knees. The path of a movement involved in industry may be *longer* than that of another, and, simply because of this, the one movement may occupy more time than the other. Further, apart from the mere length of movement, there are other factors which interfere with its efficiency. For instance, a movement which could be represented by a very jagged line might take longer to perform than one represented by a longer but straighter line.

The study of single movements therefore aims at the construction of any necessary movement out of most efficient, or least-wasteful, movement elements.

The study of groups or series of single movements has an essentially similar aim. This aim is, firstly, to eliminate from the group or series any unnecessary single movement; just as the study of single movements aims at the elimination from them of unnecessary (and therefore wasteful) movement elements. Secondly, it aims at reconstructing the group or series so that it will include only single movements made up of least-wasteful movement elements.

The question now is as to the actual process followed in the study of movements. Originally, workmen were timed with "split-second" stop

watches. By this means it was theoretically possible to discover the time taken by any particular movement in fifths of seconds. Practically, this was not possible; variable errors inevitably occurred in the starting and stopping of the watches, so that one could not get an absolutely precise result. An approximation to such a result was obtained, however, by averaging the times recorded for a large number of measurements of a movement. Along with the time occupied by any movement was recorded its spatial path, as precisely as this could be determined by merely watching it.

The fact from which the investigator seems, as a rule, to have started was that some men were able to make a much larger output than were others engaged on identical work and working under the same conditions. The explanatory assumption was then made that the actual movements of the more efficient workmen were less wasteful than those of the less efficient. It is, of course, fairly obvious that the movements of the more efficient men probably occupied less time than the "same" movements of the less efficient. The times occupied by "identical" movements when performed by men of different efficiency were therefore recorded, together with their forms. It was thus possible to compare the form of a movement occupying a relatively short time with that of the "same" movement when occupying a relatively long time. Such a comparison seems often to have suggested almost

at once in what respects a given movement was wasteful.

It was thus made possible to reconstruct a movement of relatively low efficiency by making it similar in form to a movement of relatively high efficiency. This means little more, essentially, than that methods of movement used by good workmen could be handed over to others less good. But the comparison of efficient and inefficient movements made a still further advance possible. It showed what features of any movement rendered that movement inefficient. Now the movements of the good workmen were only relatively efficient; because such movements yielded a larger output than those of workmen not so good, it did not follow that they were perfect. The imperfections discovered in the movements of the poorer workman by comparing them with the movements of the good workman were, in fact, typical of imperfections in all traditional movements. These imperfections could thus be sought for even in the movements of good workmen; and in this way it was possible, finally, to construct the forms and times for ideal movements, that is, for movements made up of least-wasteful movement elements.

Such seems to have been the character of some of the earliest attempts at motion study, and certain features of that character motion study still retains. It was not long, however,

before it was realised that the form of a movement could not be recorded with sufficient precision for motion study purposes by simply watching it. Recourse was therefore had to numerous photographs of the movement being studied. These were taken from different points of view, and at different points in the development of the movement.[93] The use of photography led very naturally to a cinematographic representation of movements. In this form motion study is termed *micro-motion* study. It may seem that a film of a movement would give as precise a representation of it as could possibly be required. As a matter of fact, however, although the films had certain advantages, such as that they allowed the investigator to watch a given movement performed at any rate desired by himself, certain disadvantages belonged to the cinematographic representations.

For instance, a workman would sometimes obscure a movement at a critical point by obtruding some part of his body between it and the camera, the obtruding movement being involved in the ordinary work of which the movement under investigation formed a part. The chief defect of the cinematograph record, however, was that it was not very suitable for teaching purposes. It must be remembered that

[93] For further details about the methods here described, see an article by F. B. and L. M. Gilbreth entitled "Chronocyclegraph Motion Devices for Measuring Achievement" in the *Efficiency Society Journal* (March, 1916); also the same authors' *Fatigue Study* (Ch. VII.).

efficient movements had to be taught as well as constructed ;[94] and it was felt that there must be possible both for the purpose of studying a movement, and of teaching a good method, a better instrument than the cinematographic film.

These difficulties led to the "cyclegraph." A small electric light was attached to that part of a workman's body, the motion of which was being studied. An appropriately sensitised photographic plate was then exposed during the performance of the movement ; and the path of the movement appeared on the developed photograph as a white line. The general character of a cyclegraph record is shown in Fig. VII. A. (except that here the path of the movement is shown in *black*). If the record were taken with a stereoscopic camera, it could be observed in three dimensions.

This record, however, presented an obvious defect, which existed also in the cinematographic representations : it was impossible to know from it alone precisely how much time was occupied by any part of the movement which it represented. In order to study the movement, or any element of it, in relation to the time occupied, the investigator had still nothing to rely upon but his not very precise stop watch records ; and it was difficult to correlate these with the cinematograph and cyclegraph representations.

[94] See above, pp. 166 et seq.

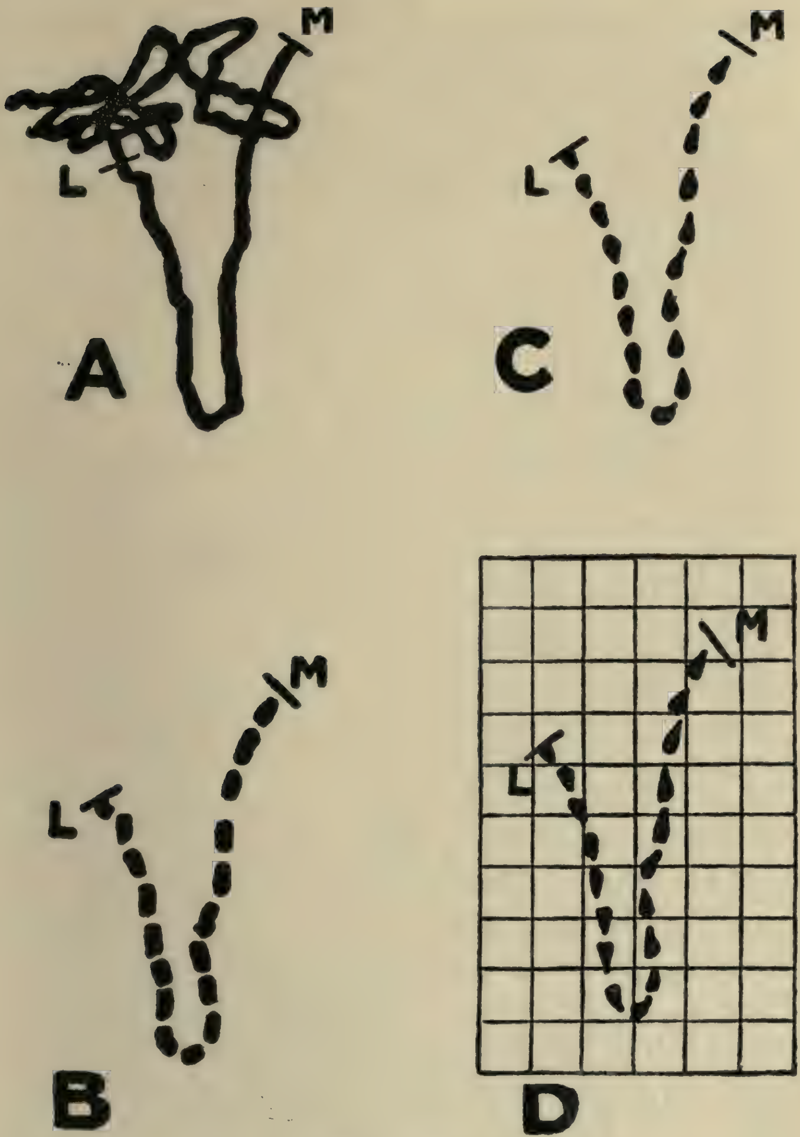

FIG. VII.

Diagrammatic Representation of Motion Study Records.

The figures A, B, C, D, indicate the results of successive attempts to record the important variable factors of motions.

This defect was overcome by introducing an interrupter of known period into the circuit of the electric light. As a result of this device, the path of the motion appeared on the developed photograph as a number of small dashes. The time taken by any part of the movement could at once be determined from such a record, since each dash corresponded to a known interval of time (Fig. VII. B).

This arrangement also showed in an instant *the relative speed* of different parts of any motion. If the dashes were close together, this indicated that the part of the movement represented by them was slower than any other part where the distance between the dashes was greater. (Relative speed could also be determined by comparing the lengths of the dashes.)

Two defects still remained. The first was that, from the study of a cyclegraph record,—now, through the representation of the time element, a *chrono*cyclegraph record,—it could not be determined *what direction* was taken by any part of the movement studied. This difficulty could have been surmounted, no doubt, by correlating the record with the actual movement; but an easier method for avoiding it was adopted. A device was used by which the dashes of Fig. VII. B appeared on the record as blunt arrow-heads, pointing in the direction taken by the movement (Fig. VII. C). So far, then, it was possible to know the path travelled by a movement, its direction, the time occupied

by it or any part of it, and the relative speed of its elements.

The second defect of the chronocyclegraph records was that they gave no indication of the *length* of the actual movement. This difficulty was overcome by means of the "penetrating screen," etc. A sheet of black paper, of the size of the space to be photographed, was cross-sectioned with white lines at specially determined distances from each other. This was then put in any desired place and photographed. For instance, prior to the making of the movement, the screen was placed so that it stood as nearly as possible where the man who was to make the movements was to stand later. It was then photographed on an appropriately prepared plate, and removed. The same plate was now used to photograph the moving light, with the result that, finally, the movement line appeared on a cross-sectioned background.[95] Since it was known precisely what spatial distance was represented by the intersecting lines on the photograph, it could be calculated, without much difficulty, just how long was any part of the actual movement represented by such-and-such a part of the movement line on the photograph. Hence, in this form of representation, there were included all the important variables of a movement: length, relative speed, direction, and time occupied (Fig. VII. D); and with

[95] Photographs shewing the "penetrating screen" will be found in F. B. and L. M. Gilbreth's *Fatigue Study* (Fig. 31).

appropriate apparatus the path of the movement could be observed in three dimensions.

The final stage in the development of motion study methods was the construction of a wire model based upon the cross-sectioned chronocyclegraph record. This showed the motion in three dimensions, and attempted to reproduce the precise length of the original movement and each of its parts. On this model was shown also the arrow-heads, so that from it the movement could be studied in as favourable a form as possible.

It need scarcely be said that, technically, this development of methods of making motion studies is highly interesting. It may be thought, however, that the various refinements described could be of little more practical value than the cruder methods used at first. It is difficult at the present time to say how far such an idea is justified.[96]

§ 4

Extensions of the "Best Method" Idea

I shall conclude this lecture by referring to three spheres in which, it seems, application of the "best method of work" idea would give

[96] For study of an actual series of movements, without the use of chronocyclegraph records, see an article by G. H. Shephard entitled "An Analysis of Practical Time-Motion Studies" in *The Engineering Magazine* (July, 1912). The work studied was that of operating at the same time a rotary furnace and a bolt-header for upsetting hot stock from the furnace.

valuable results, and in which there are no complications of a kind likely to make anyone hostile to attempts to carry that idea into practice. I wish, however, to guard against the impression that these spheres indicate, as it were, the whole area of the field within which new methods are possible, or at least practicable. There are, as far as can be seen, no boundaries to that field. The methods employed in almost all human occupations have been arrived at in haphazard ways, often as a result of economic pressure which made some method, however poor, necessary, and hardly ever by deliberate attempts to construct methods scientifically. Hence, there is probably no kind of work performed by any human being which might not be lightened by the introduction of good methods. The few new methods that I have described must therefore be considered merely as types or illustrations of what might be done universally. That we find ourselves interested in the elaboration of new methods in this or that sphere in particular, should not blind us to this fact.

The first of the tdree spheres to be mentioned is the home.[97] Of late years only has the idea arisen that the results of science might be utilised with benefit in this sphere. We can not, of course, measure effects here with the

[97] *Cf.* H. Münsterberg (*Psychology and Industrial Efficiency*, pp. 177-178); also J. Ioteyko (*The Science of Labour and its Organisation*, 1919, pp. 74-75).

precision that is possible in what are ordinarily called industries; but it is evident that if there were some saving of energy in the carrying out of household duties in every home, the total amount of energy saved would be enormous.

From the point of view of psychological science, we would begin the attempt to construct good methods here by enquiring which kinds of work and circumstance are most fatiguing to a woman. The modern house seems often to be striving to resemble a mediæval castle. Yet there is a great difference between domestic service now and several centuries ago. The woman whose home is a two-roomed cottage probably at no time has felt her household work exacting. If, on the other hand, a woman is mistress of a large and complicated house, she must have much assistance, either in the form of personal or scientific service. This is so, too, even when a house is of a moderate size only. And, therefore, as the personal service is not so easy to obtain as in the past, and as it is probably easier to obtain now than it will be in the future, it is almost incumbent upon man to utilise scientific service in the home. The question to be solved is how to adjust the home to the strength and interests of a modern woman, who is often under the necessity of relying upon herself alone. The direction in which we should look for an answer to this question is suggested by various recent household innovations, such, for instance, as the

placing of a water tap and a sink in each room, —devices which, though simple enough, often save much lifting and carrying of a fatiguing nature. I want to point out that the adjustment of the home to the modern woman's physical and mental constitution is, in principle, precisely identical with the adjustment of any piece of machinery to the psycho-physical make-up of the operative who is in contact with it. There is no difference, in principle, between the attempt at such an adjustment and the attempts that have been made to adapt shovels to the physical constitution of shovellers. If the work of the home be entitled an industry, there is here a most important sphere for industrial psychology.

The second sphere to which I shall refer is that of the primary industries, especially as these occur in Australia.[98] The farmer, who is one of the most important and least parasitic of all the citizens of the state, has hardly had his fair share of the results of science. There are, I know, reapers-and-binders, and other machines of similar character; but such skilful inventions are generally not at the disposal of the small farmer, who must work by traditional methods with the implements traditionally used. The small farmer might be helped in two ways: first, by giving him scientific machinery suitable for work on a small scale; secondly, by teach-

[98] These lectures were originally delivered to an Australian audience.

ing him something of the science of efficient movement.[99] For instance, the mere knowledge of what has been done in methods of fruit packing might be of very great assistance to the small fruit grower, whose packing is often carried out on no principle at all.

Two larger departments of primary industry may also be mentioned. The present methods of handling our [100] wheat crops are wasteful in the extreme. Apart from what these methods may cause in loss from a mice plague such as we have recently [100] experienced, the *unnecessary human energy* expended because of them must be very large. The mere sewing up of the bags must involve much time and labour in the aggregate; although this is nothing compared with the labour involved in lifting.—Again, good methods of work could, probably with great advantage, be introduced into the mining industry. No question of employer and employee need here arise, since much of the mining in Australia is done by contract, and the new methods could be adopted primarily by contract men. It would probably pay contract miners handsomely to employ a scientific expert to experiment with picks and shovels, for instance, and methods of using them.

Finally, I shall refer to a sphere of quite another kind. With the increasing interna-

[99] This would be perfectly possible through the Education Department.

[100] 1918 (Australia).

tionalism of commerce and of science, the need of a knowledge of foreign languages becomes more and more important, even from a practical point of view. There are, at the present time, industrial concerns employing numbers of clerks specially for the purpose of carrying on business in this or that foreign tongue. We can see that this is not an inevitable condition for an international concern, except in the present state of affairs. In science, however, the matter is much worse. An individual scientist who wishes to carry out research must, even at the present time, first find out what has been done upon his subject by scientists of several different foreign countries; otherwise, he runs considerable risk of merely repeating the work of another. The difficulty is no less if it is merely a question of getting up-to-date scientific information upon any subject. In the future the difficulty will be much greater because the number of languages required by a scientist will be greater than now. It seems to be obvious, therefore, that the construction of a universal language *for the purposes of science and commerce* would be a highly important labour-saving device. I am not, of course, suggesting that nations should give up their particular languages, but that there be one recognised language as a vehicle for science and commerce. Such artificial languages as exist at present show clearly that the construction of a universal language of this sort is possible, and, indeed, relatively easy.

Lecture V.

THE DESIRABILITY OF APPLYING PSYCHOLOGY TO INDUSTRY

§ 1

Different Points of View

It is important to emphasise at the outset that the question of the desirability of anything whatever is meaningless except with reference to the point of view of some person or persons. Only persons desire this or that: there is no desirability in the abstract. The importance of recognising this depends upon the fact that we are prone to regard what *we* judge desirable as desirable absolutely, without reference to anyone's desires, even without reference to our own; and we then tend to think that persons who disagree with us about what is desirable are either simply blind or partly deficient. It must therefore be realised that when a man says, "so-and-so is desirable," he means, primarily, that this "so-and-so" is in harmony with his own system of desires and interests. The man who makes such a judgment should realise that someone else may disagree with him and yet be no more unreasonable nor foolish than himself.

By the desirability of applying psychology to industry, therefore, I do not mean its desirability from any particular person's point of view,—a question easily answerable by the person himself. What I mean to ask is whether the application of psychology to industry is desirable from the points of view of the great majority of citizens: that is, whether it is in accord with universal desires and interests. This question can only be answered by considering it from the different points of view of those concerned; but if it can be shown that the application of psychology to industry is desirable with reference to the desires and interests of the great majority of citizens, we shall be justified in saying that it is desirable from a relatively impartial point of view.

In what follows I shall frequently use the term scientific management instead of the term industrial psychology; not that the two are identical in meaning,—the relation between them was pointed out in the last lecture,—but that the latter finds its proper place within the former, and that the general results of the two are the same.[101] And by scientific management I shall mean scientific management rightly conceived, and put into practice in its best forms.

So far as the relatively small number of persons called employers is concerned, the

[101] As a matter of fact, however, it may be possible to apply much psychology to industry in the absence of a scientific management system.

answer to our question is easy. The managements of industrial concerns have almost always reaped considerable harvests of profits from selecting workers on the basis of natural fitness, and from the introduction of good methods of work. Employers are, no doubt, often interested in other things besides an increase in their profits ; but this does not mean that an increase in their profits is ever outside their interests. If, then, we assume that further attempts at scientific management will yield results similar to those obtained from attempts that have been made, we can say definitely, that so far as a man is an employer, he will find it desirable to apply psychology to his business.

Consider, next, *all* persons in their function of *consumers*. Of course, since "consumers" is, in one aspect, identical with "all persons," consumers will have a great variety of interests and desires. Consider here, however, the trend of their interests just in so far as they are consumers. This trend may be indicated briefly by saying that they wish to obtain all goods at the lowest possible cost.

Now the application of all science to industry means, on the whole, that cost of production is decreased. Further, it is an economics principle that a decrease in the cost of production means, finally, a decrease in the cost to the consumer. *Finally*, of course ; for if a method of decreasing cost of production is obtained by a trust, it will probably be some little time before the

consumer benefits from it. Presently, no doubt, if profits become excessive, competition enters, and the cost to the consumer is lessened; although this is but an empirical generalisation. Assuming, however, that this economics principle is sound, then every consumer, in his function of consumer, will find it desirable that psychology should be applied to industry; since one general result of such application is a cheapening of the cost of production.

Consumers fall into three classes. There are those who are employers, those who are employees, and those who are neither the one nor the other. The members of the first of these classes will desire the application of psychology to industry both as consumers and as controllers of capital. The members of the third class will, generally speaking, desire its application as being simply consumers. The members of the second class, however, though they will desire the application of psychology to industry so far as they are consumers, may have other interests which give rise to stronger and conflicting desires. This, indeed, is what many relevant facts suggest. Now the number of employees in any modern state is relatively very large. If they judge, therefore, that the application of psychology to industry is undesirable, it will probably be necessary to answer our question, in the sense we have given it, in the negative. In any case, if industrial workers refuse to co-operate in attempts to apply

psychology to industry, then such application will be largely impossible, however desirable it may seem to others. To answer our question, then, we have to consider chiefly the attitude of labour towards the application of science to industry.

Those who are unable to understand the psychology of the wage-earner will look upon any objections he may make to scientific management as a sort of madness. "We must not forget," says a recent writer,[102] "that the increase of industrial efficiency by future psychological adaptation and by improvement of the psychological conditions is not only in the interest of the employers, but still more of the employees; their working time can be reduced, their wages increased, their level of life raised. And above all, still more important than the naked commercial profit on both sides, is the cultural gain which will come to the total economic life of a nation, as soon as everyone can be brought to the place where his best energies may be unfolded and his greatest personal satisfaction secured." The employer, and the consumer who is not an employee, will generally re-echo these sentiments, and feel some astonishment that other sentiments are possible.

That there are nevertheless two sides to this question will be obvious later. Meanwhile, I

[102] H. Münsterberg (*Psychology and Industrial Efficiency*, pp. 308-309).

shall mention two features of scientific management in operation, on which employees may not unreasonably look with some suspicion. Both may be illustrated by reference to the case of the girls who were selected for the work of inspecting bicycle-balls.

Firstly, as one result of this application of psychology to industry, 35 girls were able to do as much as could previously be done by 120. The employee immediately wants to know what happened to the 85 who were not retained. He is not comforted by your telling him that they found employment elsewhere,—in any case, you do not know that they did. Even if that be true, he replies, what is going to happen when psychology is applied generally? *All* the cases on record, he will add, show that, for any given work, fewer operatives were required after the application of psychology than before. If, then, you suppose that such application be made universally, will not that involve wide-spread unemployment?

Secondly, there is the question of the distribution of the extra profits accruing under scientific management. It is not unreasonable for labour to enquire whether that distribution has been fair. It is true that workmen under the new system have received, as Taylor has said, from 30 to 100 per cent. more in daily wages than others of equal capacity working under traditional methods. As a matter of

fact, however, the increase has generally been nearer the 30 than the 100 per cent.; and, in addition, it is known that output has *often* been increased by the new methods as much as 300 per cent. It is not altogether unnatural, therefore, if labour asks for a larger share in profits than it has been given, and if it looks with some suspicion upon a system which gives it only so much of the profits as has been given it by scientific management.

This point can be made still more forcefully. In the case of the bicycle-ball inspectors, the 35 who finally remained were paid almost double what had been paid to the 120,—that is, individually. Let us suppose,—what is probably not very inaccurate,—that the wage of the girls originally was £2 per week each. Then the wage of the girls after selection was approximately £4 per week each. Surely, you say, any system which increases a girl's wages to such an extent will be considered desirable by her! But the fact is that, if the wages are considered in the totals, *the working community* prior to selection drew £240 weekly from the bicycle-ball inspection, whereas, after selection, it drew only £140,—a *decrease* of nearly 50 per cent.

The matter can be put in still another way. It has been said that, despite appearances, the wages of the men who worked under the new system had really been individually decreased.

This somewhat paradoxical charge was supported by the contention that if a man did $2\frac{1}{2}$ times as much under the new method as under the old, and received an increase in wages of some 30 or 40 per cent. only, his pay per unit of output was much less than formerly. This charge is, of course, based upon a modification of the usual meaning of wages. According to that meaning, a man who should earn £1 per day would be considered to be earning higher wages than if he should earn 15s. per day; and under scientific management the daily pay of workmen has frequently been 30 per cent. more than before the introduction of the system.

These considerations show that the subject we are to discuss is not a simple one. They hardly suggest, however, just how complicated it is. I propose, therefore, to take it piece by piece, and to discuss separately the important questions involved in it. I shall begin by considering certain facts which occurred in the United States, and which suggest that others besides the employees themselves have felt that the objections of labour to scientific management are not altogether unreasonable.

§ 2

Scientific Management Legislation

In the year 1909 General William Crozier, at that time Chief of the Ordnance Department of

the United States, began to introduce certain features of scientific management at the Watertown Arsenal in Massachusetts.[103] The principal product of this arsenal was sea-coast gun carriages, for the manufacture of which it possessed a foundry, a forge shop, a machine shop, a pattern shop, and a laboratory. Shortly after the enterprise with scientific management was begun, Crozier brought to the Watertown Arsenal assistant officers from each of four other arsenals, and kept them there for a month or six weeks, in order that they might learn the nature of the innovations and then introduce them in the shops immediately under their control. It is difficult to be certain which were the precise features of scientific management adopted by Crozier; but they included motion study and premium payments, and probably also a free use of cards, including the "job" card (although this is not essential to the system). It was not until after two years of "systematisation" that the time studies and premium payments were inaugurated, that is, not until 1911; and they were introduced first into the machine shop. These two features were not used *in combination* at any other arsenal except Watertown, where, however, they were still in operation in 1915.

[103] For further details about the matter discussed in this section, see the following Efficiency Society Bulletins: *Scientific Management in Government Establishments* (1915, by Gen. W. Crozier); and *Efficiency, Scientific Management, and Organised Labour* (1916, by M. Chipman). *Cf.* also, the footnote to p. 275 (below).

Crozier's task was not an easy one. At the Rock Island Arsenal, in Illinois, one of the first innovations was the job card. This card carries the name of the workman, a statement of his job, the time he begins and ends it, and a few less important items. According to Crozier, the principal object of this card is to enable the cost department "to charge the cost of the job to the proper order"; but it serves "incidentally," he says, "as an assistance in making estimates for new work, and for various other purposes."[104] The union workers at Rock Island opposed the introduction of this card most vigorously, and did not cease to oppose it after its purpose had been explained to them. The management nevertheless stood firm, and the card was finally accepted. Apparently, experience of the way it was used killed the men's opposition to it; at least, no trouble arising from it seems to have occurred there since.

At the Watertown Arsenal, matters went along, at first, more harmoniously. No objection seems to have been taken to the "systematisation" features; and when the time study and premium payment were introduced into the machine shop in 1911, no hostility was manifested. After several months of successful use in the machine shop, it was decided to extend these two features of scientific management to

[104] *Scientific Management in Government Establishments* (p. 2).

the foundry. The attempted extension, however, was met by the whole of the moulders immediately ceasing work; a fact which suggests that the men in the machine shop had not been as friendly to the new system as was supposed, although no actual strike had occurred among them. Upon Crozier ordering an investigation, the moulders resumed work almost at once, and the inauguration of the new features was continued.

Much hostility to the system was exhibited, however, especially by organised labour. A strong circular was issued against the introduction of Taylorism in government departments, and an attempt was made by labour members to air the matter in the House of Representatives. Various petitions, also, were presented to the government (for instance, two in 1913), signed by the majority of the men working under the system in the government shops, urging the abolition of scientific management in these shops.

This active agitation against the system as practised in these government departments led to the appointment of several committees of enquiry. The first of these was a Special Committee of the House of Representatives, which investigated the condition of affairs at Watertown Arsenal in the years 1911-12. The report of the Committee was published in three volumes; but while various reprehensible practices were therein condemned,—although, according

to Crozier, these were *not* found at Watertown,—it was recommended that there be no legislation upon scientific management in government workshops.

As it was felt that sufficient relevant evidence had not been collected by this Committee, a further investigation was begun in 1913 by a sub-commission of the *Federal Commission on Industrial Relations* (created by Act of Congress, 1912). This sub-commission consisted of three men: Robert F. Hoxie, Professor of Economics at Chicago University; Robert G. Valentine, an employer's representative; and John P. Frey, Editor of the *International Moulders' Journal*, and recognised spokesman of organised labour in America. As a result of an apparently very thorough and careful investigation, an excellent report on scientific management was published. This is known as the Hoxie report.[105] The general conclusions of the report seem to have borne out the objections made by labour to the new system.[106]

[105] See *The Efficiency Society's Bulletin* entitled "Scientific Management and Labour," by J. P. Frey (1916); also, R. F. Hoxie's *Scientific Management and Labour* (1915).

[106] These conclusions are of considerable importance, and I shall therefore quote them. *They were agreed to by all three members of the Commission.* The Commissioners say:

"Two essential points stand forth. The first point is that Scientific Management, at its best and adequately applied, exemplifies one of the advanced stages of the industrial revolution which began with the invention and introduction of machinery. Because of its youth and the necessary application of its principles to a competitive state of industry, it is in many respects crude, many of its devices are contradictory of its announced principles,

The reports published as a result of these two investigations dealt with scientific management as it occurred *in practice generally*. (The investigations were not limited to the conditions prevailing under the system in the Army workshops.) The conclusions arrived at by the investigators do not, therefore, affect the theory of scientific management, nor do they show that it cannot be rightly applied. On the other hand, there seems little doubt that these conclusions were in general agreement with the charges that had been made both by the officials of organised labour and by those men who had worked under the system. The effect that the knowledge made public by these investigations had upon people generally, is indicated by the fact that legislation prohibitive of certain scientific management features in Army workshops was soon passed by the United States Government. In

and it is inadequately scientific. Nevertheless, it is to date the latest word in the sheer mechanics of production and inherently in line with the march of events. . . .

"The second point is that neither organised nor unorganised labour finds in Scientific Management any adequate protection to their standards of living, any progressive means for industrial education, or any opportunity for industrial democracy by which labour may create for itself a progressively efficient share in efficient management. And, therefore, as unorganised labour is totally unequipped to work for these human rights, it becomes doubly the duty of organised labour to work unceasingly and unswervingly for them, and, if necessary, to combat an industrial development which not only does not contain conditions favourable to their growth, but, in many respects, is hostile soil.

"Your investigator and his official experts are of the opinion that all the data focus in these two points. . . ." R. F. Hoxie (*Scientific Management and Labour*, pp. 137-139).

1915, when the Bill making the usual appropriations for the Army services was under discussion in the House of Representatives, the following clause was proposed as an amendment to the Bill :

" PROVIDED, that no part of the appropriations made in this Bill shall be available for the salary or pay of any officer, manager, superintendent, foreman, or other person having charge of the work of any employee of the United States Government while making or causing to be made, with a stop watch or other time-measuring device, a time study of any job or any such employee between the starting and completion thereof or of the movements of any such employee while engaged upon such work ; nor shall any part of the appropriations made in this Bill be available to pay any premium or bonus or cash reward to any employee in addition to his regular wages, except for suggestions resulting in improvements or economy in the operations of any Government plant ; and no claim for service performed by any person while violating this proviso shall be allowed."[107]

With practically no debate whatever, *this amendment was accepted by a six to one majority.* After a considerable amount of discussion, the Senate, however, rejected the amendment. Finally it was restored in a conference between the

[107] Quoted from Gen. Crozier's *Scientific Management in Government Establishments* (p. 8). See note to p. 228.

two Houses, and placed upon the Statute Book. It must be noticed that this legislation had reference to the current year, and that it did *not* include in its scope scientific management (or those features of the system mentioned in it) practised outside Army workshops. The interesting fact, however, is the large majority in favour of the amendment, for this suggests that prohibitive legislation of a much wider scope might readily be introduced.

It is thus evident that scientific management has met with much opposition in the United States, even from persons other than the actual men who have worked under it and labour union officials. I shall therefore discuss the most important of the charges that have been, or might be, made against the system. From this discussion I shall not omit any significant accusation made by labour.

§ 3

Labour's Charges against Scientific Management

(*a*) I shall deal, first, with the question of the distribution of the extra profits obtained by an industrial concern when scientific management is introduced into it.[108] This matter, however, need not delay us for long. Investi-

[108] *Cf.* F. W. Taylor (*The Principles of Scientific Management*, pp. 135-139).

gation shows that, in all the outstanding instances at least, and therefore almost certainly in *all* instances, capital has received the lion's share of these extra profits,[109] even although the proportion of them distributed to labour has often meant *large* increases in daily wages. The precise amount of increases in wages has generally been determined by practical considerations: it was necessary to induce the men to accept new conditions, and the question in any case simply was at what point the workers would consider the inducement an adequate stimulus to change their habits. Managers, of course, did not, as a rule, seek to distribute the scientific management profits on any principle of fairness. Even had they done so, they could easily have argued that, since the construction of the new methods was not due to the workmen, the lion's share of the new profits *ought* to go to capital. Granting the premisses of this argument, labour might still have been given more than it was given; but the chief point is that the way in which scientific management profits have, as a matter of fact, been distributed in the past, is no essential characteristic of the system, as wage payments constitute a very subsidiary part of scientific management.[110] The new methods aim

[109] The extra profits are not completely represented by the decrease in *labour* cost. Overhead charges per unit of output are also much decreased.

[110] *Cf.* F. W. Taylor (*The Principles of Scientific Management*, p. 34).

primarily at the making of profits (or at a saving of energy which results in more profits) and not at their distribution in any particular way. Scientific management could be associated with any form of industrial organisation ; for instance, with syndicalism. It is therefore clear that no valid objection can be taken to the essentials of scientific management because of the proportions in which the profits resulting from its introduction have been divided between labour and capital, for the simple reason that distribution of profits is not one of the essentials of scientific management.

As a matter of fact, labour has only very rarely made any objection to scientific management because of the relatively small proportion of its profits accorded to the worker. Generally, it did not know what this proportion was. The pig-iron handlers, or the shovellers, or the bicycle-ball inspectors, knew only that they received such-and-such an increase in wages ; they did not know how much the new methods meant to the management. That the financial consideration has not been the chief one for labour is also clear from the trouble at Watertown Arsenal, where, the institution being governmental, no "profits" were involved. It is now known, however, by the industrial worker as well as by anyone else, what percentage of the increased profits has, in the past, been given to labour ; and it thus becomes possible to maintain that that percentage was too small. But

labour's chief objections to scientific management point in another direction.

(*b*) Let us consider, now, the possibility that a general introduction of scientific management would cause wide-spread unemployment. I think it must be admitted that, if the new system were to be applied everywhere almost at once, much temporary unemployment would result. It is impossible to draw any other conclusion from the instances discussed in my last lecture.

Nevertheless, this again is no valid objection to scientific management, since it is no part of that system, essential or otherwise, that it should be applied universally all at once. As a matter of fact, this would certainly never be the case. Apart from difficulties in the way of such an application which would be raised by labour, there is the very great difficulty that good methods of work are not easy to construct. It is not everyone who is capable of elaborating good methods, even among those, at present relatively few, who have the idea of their general possibility. This being so, scientific management will only be introduced gradually, and the time factor may thus allow for any temporary unemployment to be, at least partly, absorbed in new industries.

Again, unemployment caused by a gradual introduction of scientific management might be

relieved in quite another way. If cost of production is reduced by the new methods, cost to the consumer will also be reduced. This may mean a larger demand for the goods concerned and thus a larger demand for labour to produce them.

Suppose, for instance, that by applying psychology to the methods of boot manufacture, it should be found possible to produce three times as many boots, with the energy now expended upon boot-making, as are produced at present. The worker says: But does not that mean that about two-thirds of the men at present employed in making boots will be thrown out of employment? No, it does not, as the following considerations indicate.

It has been shewn that a large proportion of the inhabitants of Great Britain, for example, do not have sufficient boots. Many of the poorer working-men would buy many more pairs of boots each year for themselves and their families, if they were able to buy as many as they need. If, then, the hypothetical new methods in boot-making very much cheapened the cost of the production of boots, it would almost certainly greatly reduce their cost to the buyers of them. Many more boots would thus be bought; and so great might this extra number of boots be, that *all* the boot-makers whose employment was threatened by the new methods would remain as firmly in their jobs as before.[111]

[111] *Cf.* F. W. Taylor (*The Principles of Scientific Management*, pp. 16-17).

The principle exhibited in this illustration is, possibly, of general application. The cheapening of *necessary* commodities, at least, must create a greater demand for them, and hence a greater demand for the labour used in producing them. Of course, the question may be raised just how far less costly methods of production do lessen cost to consumers; how far, for instance, cheap masonry makes cheap houses; but this question I must hand over to the economists.

There is, however, another aspect of the question to be emphasised. The objection brought against the application of science to industry under the present form, is, in principle, an objection to any invention or labour-saving device whatever. The man who thinks that labour-saving inventions, whether in the form of machines or of methods, cause unemployment, should logically, if he wishes to create the maximum amount of employment, reduce such inventions to the minimum. It is interesting to imagine the form which an application of this idea would take.

A man who had the power to put the idea into practice would probably begin by destroying all steam and other power machinery. This, no doubt, would create employment to some purpose, and at one stroke: not, of course, to rebuild the machinery destroyed,—for that would not be allowed,—but to do the hauling,

lifting, etc., generally done by the power machines. Men who had previously found themselves in a somewhat crowded labour market would now show a constant wreath of smiles, as, with cart and horse, barrow and farmer's slide, they fetched wool from Bourke or coals from Newcastle. Still, it would be well for them to treat their new fortune of work with care, and not as spendthrifts. In any case, would they be justified in using such inventions as carts, barrows, and farmers' slides? They would not; for all these are labour-saving devices.—This, however, would be all to the good,—according to the man who is aiming at the creation of an abundance of employment. There would now seem to be an absolutely inexhaustible quantity of work to be done, for men would actually carry in their arms the wool from Bourke [112] and the coals from Newcastle.[112] Even so, one method of carrying is more efficient than another; and so we would come, finally, to hauling everything about in the ways which occupied the most time and caused the greatest expenditure of energy. When all departments of life had been organised on this plan, our man would, I suppose, regard his achievement with complacence.

His complacence, however, would probably be short-lived. Would it not be found, in a very short time, that society had simply assumed an earlier form, in which it consisted of small,

[112] See Preface.

fairly self-contained groups? The supposition that, for instance, there would still be wool to bring from Bourke to Sydney if there were no steam engines to supply the power, is, in all probability, quite erroneous. Sydney and Bourke would, in such conditions, not exist as they exist to-day; and it would not pay anyone to grow wool at Bourke if it had to be transported about the world on the backs and shoulders of men. Bourke, without a railway which could supply it with food in drought, would probably not exist at all.

The fact surely is that if one were to do away with the various labour-saving devices in the world, one would, at once almost, *kill the demand for all sorts of labour,*—apart from that for the labour to construct various sorts of machinery, which is by no means small. The assumption that there would then be much more work available than now is based on the assumption that the present demand for labour would continue in altogether different conditions. And this latter assumption is false. What must be realised is that the amount of labour required in any country is not some fixed quantity, which will remain the same however social conditions alter; but that it is dependent upon the particular form which any society assumes. Of course, I do not deny that in some special instance a particular invention would cause temporary unemployment; but it is probable that adjustment would soon occur, and that there would be,

before long, a greater demand for labour because that invention had been made than there would be had it not been made.

It might be replied by the man who objects to the introduction of new methods of work because of the possibility that they will cause much unemployment, that he never thought of applying his idea in the extreme form I have indicated, and that there is no reason why he should. What I wish to do, he might say, is to accept the present adjustment as far as possible; except that I would try to improve it by preventing the introduction of further inventions. But if he is to treat his idea seriously, it would seem that it must lead him to the extreme result described. Whether this is so or not, his idea, I believe, is based on confusion and fallacy.

I shall now state a proposition which seems to me almost self-evident. This is that whether or not an invention of any sort causes unemployment depends altogether on the use that is made of it, and on the way it is brought into connection with industrial life. Consider, as illustration, a hypothetical case. Let us suppose that we live in a socialist state, which we find to be as perfect as such states have frequently been pictured. What would happen if labour-saving devices were introduced into such a state? Would unemployment ensue? Not at all; for the persons in control would, in some way or other, at once effect an adjustment, if

it were necessary. But, you say, could such an adjustment be made ? The answer is : Very easily ; for instance, simply by shortening the working day.

Thus, if in an ideal state it were found that the application of psychology suddenly brought it about that all the work required could be effected by an expenditure of only one-third of the human energy which had formerly been needed, the majority of the industrial workers would not, on that account, find themselves without occupation. Rather than that, the authorities would shorten the working day to one-third of its previous length. Cannot we imitate the ideal state ?

My conclusion thus is that the way in which it seems likely that psychology will be applied to industry, that is to say, only gradually, will not cause more than very temporary unemployment. If I am wrong here, however, I think it is easily possible for labour to secure an adjustment which will relieve the situation.

(*c*) The next labour charge against scientific management which I shall mention is that it leads to undue speeding up. This charge has been made so repeatedly that it cannot be treated lightly. It must be admitted, I think, that most of what has, in practice, been *called* scientific management, has been associated with speeding-up methods. After what I have said in earlier lectures, however, it is unnecessary

to discuss this question further here. I shall only repeat that speeding up is *no part* of scientific management rightly conceived, and that it has *no place whatever* in industrial psychology.

(*d*) I proceed to discuss another charge, to which I have so far not referred. This is that the elaboration of what are called, by scientific managers, *good* methods of work, make men into mechanisms, fasten them in a relentless routine, and destroy individuality. This results, it is said, from the standardisation of all the operations involved in any industrial process. Put into as precise a form as possible, this objection is that the standardisation of motions and times, and the regulation of a working day, even when pauses are interspersed at definite intervals throughout it, is destructive of a man's "individuality." And when it is said that standardisation of movements and times makes a man a mechanism and an automaton, what seems to be meant is that the factors standardised are thus put *outside the sphere of choice.*

It appears to me that this charge rests largely upon a confusion of thought. It is *assumed* that present-day working methods involve no laws, but leave a workman free to act as he will. This assumption is entirely false. There is no such thing as working outside of laws. The bricklayer who uses the traditional methods is

subject to laws in his work just as much as the bricklayer who uses the new methods. That he is ignorant of the fact, or fails to realise it, does not alter the matter. The pig-iron handler by the old method was as much subject to law as the pig-iron handler by the new method ; for instance, in using the old method he had to respect the laws of fatigue, at that point, at least, when he became almost exhausted. The essential difference between the traditional methods and the new ones is that the latter are often good and the former generally bad. It is not a question of a " soul-destroying " method or a " soul-preserving " method : it is a question of a good method or a bad one.

The scientific management methods of work, when good, are based upon the laws of a man's psycho-physical organism, and those of the processes required in labour. They aim at utilising natural laws as much as possible for the attainment of our ends. If, for instance, a man wishes to swim, he must either adapt himself to the relevant laws, or be drowned ; if he wishes to become a record swimmer, he must give special attention to the nature of those laws, and act in accord with them. A man who should wish to walk from Sydney to Melbourne could do so by following the coastline to the south ; but, of course, he might, if he wished to shew that he was no mechanism, start walking to the north, and only reach Melbourne after having passed through Perth. Now, what

industrial psychology says, in effect, is this: Here are certain persons with certain aims; they want to shift this pig-iron or lay these bricks with the least expenditure of energy per unit of work: let us, therefore, consider what are the best methods to use for the attainment of these purposes, and in particular, let us endeavour to apply *psychology* so that better methods may be used than those at present in practice.

I am unable to see that this can make a man more of a mechanism than he is. Is a man more a mechanism when he learns a poem by the "entire" than when he uses the more natural "sectional" method?[113] Is he more a mechanism because he rests at regular intervals in his work instead of working continuously? Is a bricklayer more a mechanism because he no longer bends to the level of his feet whenever he wants a brick or a trowel of mortar? There is certainly a sense in which the very opposite is the truth. In this sense a man is least a mechanism when he respects the laws of nature in attempting to realise his purposes, and utilises those laws to the fullest possible extent. More than one great thinker has believed that human freedom is possible only through a knowledge of natural laws.

There is, however, another sense in which the term *mechanism* is popularly used, according to which scientific methods of work *could*,

[113] See above, pp. 13-14.

in certain conditions, mechanise a man. It is sometimes said that a man becomes a mechanism, when it is meant that his life tends to be absorbed by his physical labour. If this is so continuous and exacting that thought is rendered almost impossible, it may, in a useful sense, be said that, because of it, a man tends to become an automaton. It would be a mistake, however, to suppose that good methods of work, such as often include standardised times and movements, *necessarily* involve any such mechanising of a man. If they were to do so, they would simply not be good methods. It is true that a man may be required to work so long and continuously by a method, good in itself, that he tends to become a mechanism, in the present sense of that term; but this is possible, also, when a traditional method is being used. Indeed, the possibility of mechanising a man, in the present sense, is far greater when a traditional method of work is used than when the method involves standardised times and motions; for methods of the latter kind often employ the principle of pauses for recovery from fatigue, while the older methods generally do not; and we can say, at least, that if the new methods do not make use of our knowledge of the principle of pauses, they certainly should. What must be guarded against is the use of *any* method of work for hours that are too long. When the length of the working day is such that a good method, based upon

scientific knowledge, tends to mechanise a man, in the present sense of the term, there is little doubt that it should at once be shortened.

(*e*) I come to a more important point. It has been charged against scientific management by labour that it tends to interfere with *collective bargaining*. Here, labour and scientific management seem to be in agreement as to the facts ; for Taylor himself has said that scientific management "makes collective bargainings and trades unionism unnecessary." Briefly, I think that this charge is true, and that the method of introducing the new system, or any part of it, will need to be modified in certain ways, if labour's co-operation in the use of it is to be given freely.

It must be remembered, in considering this question, that collective bargaining is one of the fundamental principles of organised labour. It may be said, indeed, to be *the* fundamental principle upon which the labour movement is based. So long as the employer was able to deal with workmen *individually*, the power was all on his side. The individual workman often needed work at once, and must therefore accept any conditions which the employer considered appropriate ; and he had thus little chance to receive justice in cases where there was a desire to withhold it. It was by *combining* and facing the employer in a body that industrial workers obtained the freedom they now possess. This,

of course, is common knowledge, and hence I shall not dwell upon it. I only wish to emphasise that labour naturally feels a sort of instinct against anything which tends to weaken its power of collective bargaining. I think that this attitude of labour is wholly reasonable.

Let us consider how scientific management tends to interfere with this fundamental principle of organised labour. To begin with, this interference occurs whenever the principle of selection of workers on the basis of natural fitness is applied in the adult labour world. No girl was retained as a bicycle-ball inspector because she belonged to a bicycle-ball inspectors' union,—assuming that there was such a union. The employer, in fact, treated each girl separately, and engaged only such as possessed a special capacity. This means that the individual worker stands before the employer once more in isolation from any group, and is therefore once more dependent, though perhaps not so much as formerly, upon an individual employer's conception of justice. The worker is not without historical evidence that this is a weak reed to lean upon.

A result not essentially dissimilar from this is associated with the new methods of work. Here it is a question of capacity *to learn* the new method, and to accomplish the set task by the use of it, which are the important factors. Both the method and task are designed by the employer: the operatives have no say in these

matters. Similarly with the increased wages that are given. The tendency thus is for the individual worker to look more and more towards his employer, and less and less towards his union, which, in fact, has never offered him so much in wages as is at present offered him by his employer, if he will accept certain new methods and conditions of work. There are now two suitors for the labourer's hand, and he naturally tends to bestow it where more is offered in return.

Further, experience shows that, in practice, the operation of scientific management tends to weaken group solidarity. It is not difficult to see why this should happen. The increases in wages offered under the system are often so very *unusual*, that the individual's acquisitive instinct is strongly excited. The good workman can easily gain the offered reward simply by following the instructions that are given. Why, then, should he care whether he belongs to a union or not? The poor workman regards his more skilful comrade with jealousy, which sometimes becomes resentment, especially if, because of the good workman's skill, tasks are set which cannot be made by the majority of workmen without speeding up. Again, when, as sometimes happens, premiums are paid to *groups* of workmen, the solidarity of the group is affected detrimentally, the quick man feeling that he is carrying the slow man on his shoulders, and the slow man resenting the impatience of the quick man. Hence, a spirit of jealousy and

opposition enters among the workmen themselves, who before faced the employer as a united body.

Such results seem to have come from scientific management even where it has been well carried out; but, of course, where it has been badly carried out, these results have been much intensified. It would therefore seem that, if labour is to co-operate willingly in attempts at scientific management (including attempts to apply psychology to industry),—and without such co-operation the full benefits of the new system and ideas cannot be attained,—it will be necessary to find a practical method of application which will recognise and respect, and in no way threaten to destroy, that fundamental principle of labour's development, *collective bargaining.* I shall suggest presently the form that such a practical method might take (see pp. 272-278).

(*f*) Let us consider another important labour charge against scientific management, a charge that does not seem to be so difficult to answer as that just discussed. This is that this whole new tendency in industrial methods destroys craft skill, and thus takes from the worker one of the most valuable of his possessions. An objection to scientific management, and especially to industrial psychology, on this score has been made repeatedly and vigorously. It has been said that the possession of craft skill by the worker is the great reason why the employer is willing to pay for his services at a fair price;

and that if this skill be taken from him, he is no longer of so much value as he was. Industrial psychology, however, takes from the workman his craft knowledge; what is traditional it replaces with some new skill based upon science; this new skill is no longer simply in the possession of the workman; it now belongs primarily to the employer, who gives it to the workman as he sees fit. All this strengthens the employer, it is said, and weakens the employee.

Apart from the fact that the scientific manager frequently tries to induce the worker to utilise a new method in carrying out any single piece of work, it is also said that a prime characteristic of the new system is to increase to an excessive degree the specialisation tendency in modern industry. As a result, what could be considered a craft before the introduction of the new system, is afterwards a number of specialised processes, every one of which is performed by a different man. This means, it is said, the disappearance of skilled labour; for the man needed for any one of the specialised processes requires simply one specialised capacity,—for which he can be tested, say, by a reaction-time apparatus,—and no particular training. Apprenticeship, in the ordinary sense, disappears also: any man can learn the work for which he has a natural bent in a few days or weeks. While the movement may offer high wages now, it is added, the inevitable final result of the conversion of all

labour into unskilled labour will be to lower wages. Finally, the destruction of craft skill, it is said, removes all interest and pleasure from a man's work; for what interest or pleasure could be got from constantly screwing nut number 21 or 108 on to an automobile?

It must, I think, be realised that this charge is complex; and in order to deal with it adequately we must make certain distinctions.

Firstly, the charge says *both* that scientific management destroys craft skill, *and* that the possession of craft skill is the great asset of the industrial worker. The former of these two statements is true, the latter false. The most valuable possession of the worker is the union, and the power that he possesses by means of it for collective bargaining.

It is not the serious thing it is often supposed to be that industrial psychology takes craft knowledge and craft skill from the worker. Provided the principle of collective bargaining is not thus affected detrimentally, the worker suffers in no way from this. That he need not suffer is obvious from the patent fact that some of the strongest unions in this country[114] are unions of unskilled labour. If we ask, further, what the destruction of traditional craft skill involves, we find that it consists essentially in the substitution of an efficient method of work

[114] Australia.

for an inefficient method. And it seems to me that a bricklayer, for instance, who had learned Gilbreth's method of bricklaying, would possess *more* craft skill (and a greater commercial value) than the man who knew the traditional method only. This, of course, might not always be the case. It might not be so when a craft is broken up into a number of specialised processes. Let us consider this disintegration of crafts.

Here, again, we must make a distinction. It is true that industrial psychology may often speed up the specialisation tendency; but this tendency is by no means a feature of industrial psychology only. On the contrary, it is apparent throughout the whole history of labour, although it has been especially manifest since the beginning of the industrial revolution. It has been found,—for fairly obvious reasons which need not here be recounted,—that specialisation is often a means to greater industrial efficiency. It thus happens that industrial psychology often furthers this tendency: indeed, sometimes at a bewildering speed.

It must be admitted, then, that industrial psychology sometimes increases specialisation, and that this may often involve a destruction of what is called craft skill; but no valid objection to industrial psychology, from the point of view of the worker, can be based upon this ground alone; for the destruction of craft skill, as we

have seen, need not be detrimental to the worker (that is to say, financially, and in his relation to employers). There remains to be considered, therefore, only the objection that all specialisation is "soul-destroying," or that it removes interest and pleasure from work.

Now the fact seems to be that it is not specialised work in itself that is "soul-destroying," but a performance of such work for very long periods. Of course, *any* work may prove uninteresting. The mere fact that it *is* work, that it *has* to be done whether we want to do it or not, is often sufficient to make intolerable an occupation which, were we perfectly free to engage in it or abandon it, would appear full of interest. Golf would prove highly tedious if every man had to spend forty-four hours per week in "playing" it. It would seem that mere specialisation is not the "soul-destroying" factor in work. If it were, the outlook would be black enough, since the specialisation tendency has an octopus grip on modern industry. It is this which renders the idea that each workman should make "one whole thing" so very impracticable. A railway engine is "one whole thing," one would suppose; but it is altogether impossible for one man to make a railway engine. One man might make a chair, a table, a bedstead, a cake of soap,—although one wonders whether he would really "express himself" in a cake of soap. The fact seems to be that, in favourable conditions, men feel an interest in

highly specialised work, provided they understand its general function. The man who does a very small part of the work necessary for the manufacture of a cake of soap, may feel as great an interest in his work, if he understands the general routine of the whole process of the manufacture of soap, as if he made the whole cake himself.

Suppose, however, that this is not the case; and that men who are engaged upon specialised work find their working existence barely tolerable. In these circumstances, it would seem that the hours of work should be reduced, in order that men may find, in social activities outside their work, the interest and opportunities for "self-expression" not otherwise offered to them. It would probably be a good formula to adopt that the more specialised the work, the shorter must be the working day,—a formula illustrated, for instance, in the working hours of telephone operators.[115]

Finally, there is another point to be mentioned. It must be remembered that by no means all labour is skilled labour. Therefore, the labour charge against industrial psychology which we are now discussing is, strictly speaking, only a *skilled*-labour charge. It is, in fact, a cry of skilled labour in fear of the possibility of becoming unskilled labour, and thus suffering a reduction in wages and *prestige*. Among the

[115] See above pp. 127-128.

reasons urged by workmen for the abolition of scientific management in Watertown Arsenal was this, that the system often gave unskilled men an opportunity for making more wages than skilled men.

It seems, therefore, that the present charge, notwithstanding the prominence that has been given it, does not come from the very heart of the labour movement, but represents merely the skilled section of workers. In so far as it is grounded upon a certain jealousy on the part of the skilled man, as seems sometimes to have been the case, it is hardly worth discussing; but it *is* worth discussing in so far as it represents a fear that the strength of the industrial worker is being undermined. If, however, the foregoing analysis is, generally speaking, along the right lines,—it is not meant to be exhaustive,—and if, at the same time, the principle of collective bargaining is firmly maintained, there is *no valid ground* for the present charge of labour against industrial psychology or the wider system of scientific management.

(*g*) I shall now briefly discuss the charge that scientific management is "undemocratic." "Organised labour has declared," says Mr. Frey, "that scientific management is essentially autocratic, a reversion to industrial autocracy which forces the workers to depend upon the employer's conception of fairness and justice and limits the democratic safeguards of the

workers. . . . Industrial democracy, as we understand it, is that condition in the industries which acknowledges and accepts the right of labour to a collective voice in determining what the terms of employment shall be, and the conditions under which labour is to be performed. It gives practical application to the principle that government in the shop, like government in the nation, should be by the consent of the governed." [116]

The charge of labour made in the first part of this quotation is undoubtedly true. In order to prove this, it is merely necessary to refer to the essentials of the new system, and to such illustrations of its use as I have given in my last lecture. The movement begins always from the side of the employer, who elaborates in theory what is to be put into practice. It is thus vital, if the system is to be put into operation at all, that managerial instructions shall be carried out minutely. The employee is instructed to do this or that,—to pause at certain stated times, to perform his movements in such-and-such a way, —often without his understanding in the least what the innovations mean. Even if he is treated as an intelligent being and has the general purpose of the novel methods explained to him, he must still accept them without question ; and he must also receive as reward an amount determined altogether by

[116] J. P. Frey's *Scientific Management and Labour* (p. 17).

his employer. And whether he is treated as an intelligent person or not depends, of course, upon any particular employer.

It has to be accepted that workers resent a general tendency in this direction; and it must be recognised that one of the ideals of labour is "democracy in the workshop." There is in this no question of any attempt to determine the *business* side of industries; but there is a desire for a joint control (with capital) of the conditions obtaining in the workshop. Employers may, on the one hand, refuse to recognise that this is a labour ideal, or, again, they may oppose every effort to realise it. There is a wide-spread tendency, on the other hand, to admit the ideal, and to grant concessions to labour in accord with it. What I wish to point out here is this: that labour will resent the introduction of *any* system which tends to increase industrial autocracy, and that, therefore, unless some way of getting rid of this tendency in scientific management can be devised, the introduction of this system will be opposed by labour, with the consequence that its full advantages will not be attainable.

It is of interest to note here that no one recognised the tendency of labour to demand democratic conditions in the workshop better than Mr. Frederick W. Taylor. He went out of his way, almost, to prove that "*Scientific management is the essence of industrial democracy.*" "It substitutes the rule of law," he

says, "for arbitrary decisions of foremen, employers and the unions . . . it gives a voice to both parties,—to the worker in the end equal voice with the employer,—and substitutes joint obedience to fact and laws for obedience to personal authority. No such democracy has ever existed in industries before."[117]

But the conditions here indicated by Taylor are not what would ordinarily be called democratic. Obedience to "facts and laws" is all very well; the question is who is to decide what particular "facts and laws" are to be obeyed. The scientific management answer is that this decision shall rest with the management: and it is precisely this that is regarded by labour as a "reversion" to "industrial autocracy." In practice, the autocracy is much greater than in theory, because the management generally introduces the new system with an eye to its own special interests.

(*h*) The last charge I shall consider is only a possible charge. So far as I know, it has not been made by labour as yet. It concerns that part of industrial psychology which aims at selection of workers on the basis of natural fitness. It might be said, I think, that selection would limit a workman's freedom in the choice of a vocation, a man under such a system possibly being told off, for instance, to inspect

[117] *Cf.* J. P. Frey's *Scientific Management and Labour* (p. 17).

bicycle-balls, whereas, if left to himself, he would become, say, a bricklayer.

If a possible objection of this kind is to be worth discussing, it should, I think, mean two things. It should mean, firstly, that there would be *much* less freedom to choose a vocation under a selection system than there is at present. If the freedom under selection were only a *little* less than now, then, considering the benefits that would be likely to accrue, it would seem that we might very well be satisfied with that amount. Secondly, the objection should mean that the freedom of choice which men are now able to exercise as regards a vocation, has results that are *far more* valuable than those likely to come from the hypothetically lesser freedom possessed under selection.—There seems to be little evidence for either of these propositions.

It is simply absurd to suppose that the majority of men have much freedom in choosing a vocation under the present system. A particular man, no doubt, may not *feel* that there are any bounds to his freedom in this respect, simply because he has never thought of adopting one of more than a very few vocations, and as regards these few he can act as he pleases. He may become a bricklayer, or a carpenter, or a blacksmith,—perhaps as his fancy determines. Where, then, is the limit to his freedom of choice? It is in the fact that the vocations among which he can choose are *very* few; in

numerous instances, indeed, there are not even several among which to choose, since economic pressure often drives a man, or a youth, to take what happens to come his way. A man is generally ignorant of the factors that determine the opportunities which come to him ; but no one doubts that they are determined. If we look carefully at the " free " man under the present system choosing his vocation "freely," we see that there is little freedom of choice in the matter. When it is not economic necessity that determines the precise vocation a man adopts, it is often the advice of someone who happens to be in touch with him,—advice the wisdom of which cannot be guaranteed.

Under a selection system all vocations would be theoretically open to anyone. Practically, every man would find himself debarred from some. For instance, engine-driving would be closed, as it is now, to those who are colour-blind. But testing a man's capacities would generally show that he was almost equally fitted for any of several vocations ; and among these he could exercise his choice. There would thus be, under selection, at least as much freedom in the choice of a vocation as there is at present, and there would probably be *more*.

It is necessary to add that any selection system would need to be carried out with considerable elasticity. The vocational advisory

committee[118] for youths about to begin work would, as far as possible, limit itself to the giving of *advice.* It would not endeavour, nor should any other authority endeavour, to enforce this advice ; and it should always be ready to reconsider any case which gave trouble.

It is unnecessary to consider in detail whether the results of the present system of "free choice" are more valuable than those likely to accrue from the choice possible under a selection system. I shall only say that it seems *evident* that they are not. Consequently, this whole objection falls to the ground.

(*i*) What, then, are the conclusions that we are justified in holding concerning labour's charges, actual and possible, against scientific management and industrial psychology ?

The majority of these charges, we must say, are not proven, as a rule because they rest upon confused thought and insufficient analysis of the precise meanings attached to them. Most of them, no doubt, are true enough of the *practice* of the ideas we have been discussing ; but they do not touch the essentials of scientific management, and they are altogether irrelevant to industrial psychology. The great fact to be insisted upon is that the new methods prevent waste of human energy, and *all* the charges that have been made, or, in my opinion, that *can* be made, are only

[118] See above, pp. 150-151.

valid against this or that use to which these methods are put, that is, against the manner in which they are practised. This is true even of the two charges to which any weight was allowed, namely, that the new methods interfere with the principle of collective bargaining, and that they are undemocratic. Even these evident tendencies of the new methods are not essential to them, as we shall presently see more clearly.

Experience suggests, however, that it is not sufficient to show that certain of labour's charges against scientific management are baseless, if we would put an end to them, and thus advance the possibility of clearly considering the really difficult points. Those who make these charges will not be convinced by argument. Since this may seem a strange and deplorable fact, let us attempt to understand it. In order to do this, it is necessary to distinguish between the causes of a man's actions and the reasons he gives for them. Recent psychology has proved beyond doubt that, unconsciously to a man, the two are often different. No insincerity is here involved: the fact simply is that certain psychical forces express themselves as what we call "reasons" for our conduct. Now, we already know the reasons given by labour for its hostility towards scientific management. There remains, therefore, the task of seeking for the causes of this hostility in the actual experience of the labourer: that is, the task of attempting to *understand* the psychology of the relevant labour attitude.

§ 4

The Psychology of Labour's Attitude

We have reached a point in our argument where industrial psychology, as conceived in these lectures, makes contact with what has been called social psychology. For the phenomenon to be considered here is a widespread attitude of will; and, in order to understand this, it is necessary to examine the kind of effect that present social arrangements have upon the mental life of a certain large body of persons.

As we read lists of complaints made by labour against scientific management, we can hardly help feeling, I think, that all the various items represent attempts to express something which, even at the end, remains unexpressed. Side by side are placed objections that are trivial and important: as though the important objections were not adequate to condemn the system. A charge is made: labour stands back for a moment, regarding its accusation. "Yes, *that* certainly," it says, "but also *this too*"; and another charge is made. This also proves insufficient, and another, and still another, is made; yet the accuser ever seems to feel that all his charges are inadequate. Hence, he repeats them in a variety of ways, and rejects none as too small, provided it seems to tell against the system.

To understand this phenomenon we must begin by recalling a very general proposition, which expresses an empirical law of psychology. This is that a person tends to be indifferent to whatever does not seem to him to affect his dominant interest or purposes. The fact thus indicated is so well known that I shall not pause to illustrate it: I shall proceed at once to a consideration of the form in which it occurs among industrial workers.

It is not difficult to state where the dominant interest of the worker lies. He wishes to have a comfortable home, and a family; and to obtain security against sickness, unemployment, and want in old age. In a sense, no doubt, these aims are universal among men; but those to whom "fortune" has made them easy of attainment often find their *chief* interests in other things. It is because the worker feels that these common human goods are only just within his reach that his whole attention is turned to attempts to secure them.

It thus comes about that the labourer is *initially indifferent* to the whole efficiency movement. What will it do *for him*? Will it secure for him the things that he most desires? Will it banish from his life the fear of the fall of the Damoclean sword of sickness and unemployment? Will it assure him of safety when he is old? If it will do these things, he will be interested in efficiency, and co-operate in any attempt

to make it universal. If it will do none of these things, then what is efficiency to him? As it does *not* seem to help him to secure what he wants,[119] the worker finds no interest in the efficiency movement.

And there the matter might rest but for the fact that efficiency is soon brought into very close contact with the worker. What he then gradually comes to feel is that it will not do to treat this thing with *indifference*, since it seems, so far from aiding him to gain security, to be removing from him such means of security as he possesses. Scientific management thus comes to excite both his *anger* and his *fear*.

There are here two chief facts to be noted.

The *first* is that scientific management in practice has often been positively painful to the worker. This does not condemn the system in its essentials; but it explains much of labour's hostility towards it. Labour has known scientific management as a system under which it was often necessary to speed up; and the "driven" feeling in such circumstances is painful, and at a certain stage becomes intolerable. *Anger* is excited against the thing that causes the rush; and as the most obvious features of the new system were usually the stop watch and the premium, hostility was shewn to these.

[119] A high wage for a special job is, of course, not necessarily the same as security.

Even where speeding up did not occur, conditions of work were often rendered unpleasant because of the insistence upon "task" work. This question is a highly difficult one. It would seem that any satisfactory organisation of society demands it. If we are to depend upon one another, we must know just when we can be certain to get this or that commodity. The bread carter must come at his usual hour, or we are annoyed; yet when the bread carter regularly reaches the various points in his rounds at specified times, he is essentially on "task" work. So is the newspaper editor who must have his leader ready by twelve o'clock; the lecturer who must have his lecture prepared by a certain hour; the student who must know his subject by December.

In the workshop, "task" work is the condition of there being no unnecessary delays. If one workman wants a piece of mechanism by ten in the morning, some other workman must have that piece of mechanism ready for him at that time. It might be possible to attain the required end by having always ready several pieces of each kind of mechanism; but even so, it is probably necessary to know approximately when any workman will finish his job. Practically, this means that the time allowed for a job becomes fixed.

Now, it is definitely unpleasant to have to work continually with one eye on the hands of

the clock. This is so even when the time allowed for work is reasonable. Men of nervous temperament,—and we should not forget that modern machinery with its speed and noise has a considerable effect upon the sensitive nervous system,—are sometimes almost incapacitated by the consciousness that their work must be ready at a given time. When the times set for work are too short, however, the results upon workmen may be serious; but even supposing that they have always been fairly reasonable in scientific management institutions, I think we can trace some of the hostility of labour to the system to the mere fact *that they have been set*, and to the effects of this on the experiences of workmen.

The *second* fact is that the practice of scientific management has led to the workmen experiencing a sense of *loss of power* or insecurity. This is perhaps the chief point to be noted, for it has excited *fear*, and hence hostility. This loss of power is due to the fact that, under the new system, the individual has always faced the employer as a unit. His bargaining capacity has depended entirely upon what he happened to have *in himself*. If he were the man the employer wanted, well and good: he received good wages and his ego expanded itself; but if, for any reason, the employer presently found him unnecessary, then he must go at a moment's notice, and try individually to bargain with some

other employer.[120] In all this it is quite true, as Mr. Frey says, that the worker is at the mercy of an individual employer's conception of what is fair and just.[121] If it ever seemed to a particular worker that he had been treated unfairly, he could not lay the matter before his union, and thus get redress if injustice had been done. The employer insisted on dealing with the men separately. What would have happened, indeed, had a bicycle-ball inspector's union demanded that a certain girl should not be dismissed, quick reaction-time or not? Surely the scientific manager's calculations would have gone all awry!

But, you say, why did not the men stick together? Why did they consent to be treated separately? The answer is simple: because of the inducement held out in the form of increased wages. Labour, in fact, has come to feel that the increase in wages offered under the new system is a mere bribe, offered to destroy the protective rules of unionism. This is not correct in fact; but it is correct in the result. It has been found that the spirit of solidarity among the men in scientific management workshops was always weak, if not dead. The new system emphasised the individualistic qualities

[120] This is probably not true in the best applications of Scientific Management now. *Cf.* F. B. and L. M. Gilbreth (*Applied Motion Study*, "The Three Position Plan of Promotion.")

[121] See above, p. 257.

of the men. This meant that if there were a genuine grievance, at any time, on the part of some operatives in a workshop, their fellow workers were disinclined to support them, because of the fear that by so doing they would possibly lose favour with the management. Since the solidarity of labour has been its strength, a system that weakens labour solidarity will naturally be regarded with hostility by discerning workmen. Mr. Taylor claimed that no strike had ever occurred in a scientific management institution. The Hoxie commission discovered that this was not entirely exact, although there did seem to be relatively few strikes under the system.[122] Labour explains this by supposing that the system interferes with labour solidarity.

Fear, then, excited by a sense of lost power, and by the anticipation of a still greater loss of power in the future, seems to me the chief psychical cause of labour's hostility towards scientific management. It is because this fear never dies that labour's list of charges against the new system is never ended.

Is it impossible to remove the cause of this fear?

[122] See F. W. Taylor (*The Principles of Scientific Management*, pp. 28 and 135; and *cf.* J. P. Frey (*Scientific Management and Labour*, p. 23).

§ 5

Practical Suggestions

We have seen clearly enough just why labour is hostile to scientific management. The question to be discussed now is whether there is any method for combining the practice of the new system with the principle of collective bargaining, whether, in short, the new system can be applied without weakening labour unionism. It seems to me that an essential condition of this possibility is a further democratisation of the workshop; that is to say, it would seem that there will be conflict between scientific management and labour principles except in a system of "industrial democracy," as this is understood by labour. In explanation of my meaning, I propose to give an account of Mr. M. Chipman's conclusions from an investigation of scientific management at Watertown Arsenal.[123]

(*a*) Mr. Chipman, an exponent of the principles of scientific management, and an advocate of its general application, was requested by a number of workmen employed at Watertown Arsenal to act as their counsel, to investigate their complaints, and to present a brief to the Secretary of War on their behalf. This request was made after the men had vainly tried for

[123] See M. Chipman's ***Efficiency, Scientific Management, and Organised Labour*** (1916.)

two years to get the system, introduced by General Crozier, modified or abolished. Mr. Chipman acceded to the request, and agreed to act without fee ; but he stated emphatically that he would do nothing whatever unless more than one half of the employees in the affected departments of the arsenal signed statements that they were opposed to the system. A list of questions was therefore drawn up, and sent by post to the homes of the employees so that each might answer the questions as much as possible free from influence. A majority declared against scientific management, and Mr. Chipman began his investigations.

These investigations covered eleven months. They aimed at discovering the real grounds of the complaints that had been made, and, with this end in view, information was tabulated as to the relative numbers making this or that complaint, the relation between type of complaint and type of work, the ages of the men concerned, etc., etc., Among this information was the following :—

A majority of those opposed to the system were *non-union* men.

Those opposed earned *a higher average daily wage* than those not opposed.

Of the 214 men opposed to the system,

193 had an average age of 40·2 years ;
143 were married ;
112 had children ; and

200 had worked at the arsenal an average of 6·47 years.

Of the 202 men working in departments where time study and premiums were in operation,

183 were opposed to "the Taylor system";
182 were opposed to time study;
140 stated why they were opposed to time study;
169 were engaged on premium work;
154 stated why they objected to premiums;
84 stated that the system had treated them unjustly;
82 stated just how they had suffered injustice; and
146 had been "time studied."

The complaints made by the men were of the following character: that opportunity had been afforded low-class workmen for earning premiums at the expense of high-class workmen; that one high-class workman had been afforded opportunity for earning premiums while another had not; that the times set for the various tasks had been too short; that the shovel insisted upon by the time study man was too large; that the methods prescribed by the time study man were often bad; that difference of weather conditions affecting out-door work had not been taken into consideration; that shop accidents had increased; that the health of the men had deteriorated; that there had arisen

a general distrust between management and employees.

As a result of his investigations, Mr. Chipman concluded that "many of the complaints of the workers were entirely justified."[124] This conclusion is of great significance when it is borne in mind that the arsenal was a government workshop, so that there would be less likelihood of "driving" features here than in private concerns. As Mr. Chipman was an efficiency enthusiast, the condition of affairs at Watertown brought him to a sudden standstill, and led him to the opinion that "there is something radically wrong with the *Efficiency Movement*."

This radical defect seemed to him three-fold. Scientific management in practice, he says, lacks three fundamentally important things. These are:

(1) An adequate system of industrial education.

(2) An adequate recognition of the principles of democracy in industry.

[124] General Crozier writes (*Scientific Management in Government Establishments*) that the system which had been installed at Watertown Arsenal was part of the *Taylor System* (p. 1): and that "The internal evidence at the Arsenal itself has been of a state of the utmost harmony and good feeling" (p. 4). Apart from the fact that this peculiar harmony seems to have been apparent only to the General, it is of considerable interest to note that Chipman (*Efficiency, Scientific Management, and Organised Labour*, p. 13), writes that in his opinion "the system in operation [at Watertown Arsenal] is not either the Taylor System or Scientific Management according to the principles of Frederick W. Taylor."

(3) An adequate conception of, and sympathy with, the *sociological and economic aspirations* of the worker.

Mr. Chipman, however, was not discouraged. He had found the cause of the failure of scientific management: that was a step towards the removal of its defects. He thus proceeded to make a number of recommendations "for the consideration of employer and employee, organised and unorganised labour." It appears to me that these recommendations are along the lines upon which development *must* proceed if the full benefits of scientific management and industrial psychology are to be obtained. I shall therefore quote them. They are: [125]

"First: That scientific management shall include within its code of principles an adequate system of industrial education. That this education process shall include a course of study in the principles of management, and the underlying principles of time study, routing, etc., etc.

Second: That no time study be made covering the operation of any worker without his consent.

Third: That no premium or other bonus system be introduced without the consent of the workers.

[125] Quoted from M. Chipman, *Efficiency, Scientific Management, and Organised Labour* (pp. 12-13). It is interesting to compare Mr. Chipman's suggestions with the *Whitley Councils* and *Shop Stewards' Movement* in England.

Fourth: That an adequate system of representation be established as a basis of co-operation between employer and employee.

These recommendations in more detail involve:

(1) If the time study is right, if the method is right, if the time study man is right, and if the worker knows the meaning and object of the time study, and co-operates in taking it, then the consent of the worker to a standard time, or piece-work schedule, is obtainable upon an intelligent basis.

(2) It should be a principle of scientific management that no time study shall be accepted as the basis for standard time, or piece-work schedule, until the same has been approved by the worker, or a committee of workers.

(3) The method of approving or disapproving a time study shall be upon the predetermined factors of proper time study, and not upon the basis of guess-work or prejudice.

(4) In all cases, considerations of a time study must be upon the basis of fact and not upon fancy or mere contention. In case of contention, however, the time study should not be forced into the piece-work schedule, but the educative process

be developed to a point where the consideration of the time study becomes an equitable one.

(5) The workers in each department should elect or employ a committee of practical men, with knowledge of time study and the general application of scientific management, and these men should supervise, in co-operation with the management, the taking and application of time study data.

(6) Premium or bonus methods should not be introduced without the understanding and consent of the worker.

(7) If efficiency rewards or premium methods of wage payment are introduced, it is seriously recommended that the basis of payment be average long time service, and not a job basis of measurement."

To this statement of Mr. Chipman's suggestions I shall only add that the principle of industrial democracy which animates them is almost daily finding a wider acceptance among employers of labour.[126]

[126] Writing in *The Sydney Morning Herald* (Sept. 7th, 1917), concerning the attitude of the men in the recent strike, Professor R. F. Irvine says: "Behind it all, too, was an instinctive repugnance to the kind of autocracy which lingers in the phrase 'master and servant,' *an autocracy which the war is making as obsolete as the dodo, except in Australia*." [Italics mine.] (The strike referred to began in certain departments of the Government Railways of N. S. Wales, on August 2nd, 1917, as a result of the introduction of the job card into certain railway workshops).

(*b*) I pass now to another question, namely, the question of the distribution of scientific management profits. I suggest that a larger share of these profits be given to labour than it has been the custom to give, and that part of this extra share be given in the form of a shorter working day.[127] My reasons for this suggestion are partly extremely practical, and partly ideal. On the one hand, the inducement offered to labour to accept new conditions should be something permanent, not something of the nature of a bonus or premium which ends with every job. Such forms of payment may be retained; but something more permanent might well be given also, if the willing co-operation of labour is to be gained. On the other hand, only when a man does not expend his whole available energy in his daily work, is that exercise of his reasoning and imaginative faculties, in which his true dignity consists, possible. A day's work at the present time often uses more of a man's energy than should be used, if regard is had to his health; or, when it does not injure his health, generally leaves him with no reserve of energy for other interests.

It is probably not realised generally that work with modern machinery, performed during working days of the present length, often has a detrimental effect upon health. That the work-

[127] *Cf.* F. W. Taylor (*The Principles of Scientific Management*, pp. 135-139); see also the second note to p. 231 of the text.

ing day of telephone operators, for instance, in Sydney, is approximately six hours, and that a Canadian Commission recommended that it should not be longer than this, should make this fact easy of credence. I shall, however, give some confirmatory evidence. No completely satisfactory statistics concerning the health of industrial operatives have as yet been collected, although in a reasonably short time, as a result of such measures as the British Workers' Insurance Act, under which the illnesses of operatives are recorded and classified, this defect should be remedied. Such figures as we possess are nevertheless quite sufficient to indicate a general tendency.

At the end of 1905,[128] about seventy million persons had received benefits under the German Working-men's Insurance System. This system required a tabulation of industrial diseases, and included in its scope a number of sanitoria for the treatment of operatives temporarily incapacitated. These institutions rendered a close study of working-men's illnesses possible. It was found that large numbers of industrial workers suffered from the same types of illness, and that certain sorts of disease were rapidly increasing among them. In 1905, two physicians who had been engaged professionally at an industrial sanatorium, wrote as follows:

[128] The facts and quotations here given are taken from Josephine Goldmark's *Fatigue and Efficiency* (pp. 103-107).

"The increase of diseases of the nervous system among working people in the last decade is a fact that is now firmly established by extensive and carefully conducted statistical inquiry. . . . Neurasthenia . . . is steadily increasing in frequency and in severity. . . . Though, for some years, not only the laity, but also the chief medical experts on neurasthenia . . . overlooked the working classes in relation to this disease, this attitude is now radically changed. On all sides, in the clinics and physicians' offices, and by the managers of the large insurance funds, proofs of the enormous increase of neurasthenia as a cause of inability to work are being presented."

Again, in a recent report, the physician-in-chief at the Beelitz Industrial Sanitorium wrote thus:

"In the course of the year (1909) 1,815 men and 800 women were treated. . . . Of the 1,815 men, 1,206, or in round numbers 70 per cent., were nervous cases. The exciting cause of the breakdown . . . in by far the largest proportion arose from overstrain of their daily labour.

Of the female cases, more than one-seventh, or 128 of 803, were anæmic and chlorotic. Among these, one half of all suffered from nerve strain, although other complications might be present."

The prevalence of neurasthenia, compared with that of other illnesses, may be suggested

by comparing the numbers of working days lost by patients at the Beelitz Sanitorium from different kinds of illness. The following table gives this comparison.

Disease Groups.	*Total Number of Working Days lost from Time of Cessation of Work to Time of Discharge from Sanitorium.*
Infections	433
Poisonings	1,259
Malnutritions	10,634
Skin, muscles, joints, etc.	6,112
Nervous disorders	70,040

The assistant physician at the same sanitorium, in an article on "Heart Disease among the Working People of Berlin," writes as follows :

"In coming to the class of cardiac neuroses it is to be remarked that nervous affections of the heart among Berlin workmen are very common, as may be inferred from the extraordinary prevalence of neurasthenia."

Another doctor writes in the same strain :

"How alarming the increase of . . . neurasthenia among working people has been in the past 10 years is shown by the records of the sick benefit funds, the polyclinics, and the hospitals. . . . Similar figures are shown by the sanitorium at Zehlendorf, where the highest percentage of neurotic patients were handworkers and skilled workers, with whom the combination of physical and mental strain reacted destructively on the nervous system."

Notwithstanding the tendency of German workmen towards neurasthenia, the fact was so little recognised that the doctors felt the need of *emphasising* it. They stated specifically that they found no differences between the neurasthenia of the industrial worker, and the neurasthenia of the mental worker of other social classes. The symptoms and conditions were the same.

Further, they were assured that the nervous breakdown of industrial workers was largely due to "industrial overpressure." To quote from a recent American study of foreign insurance systems: "The authorities insist that increase of sickness is genuine and is due in Germany to the stress and strain of modern industry. Hours of labour are from 8 to 15 per day. The large stores, for instance, open at 8 a.m., and close at 8 p.m., allowing one hour for luncheon. It has been ascertained that in those factories where the hours are longest, the greatest number of cases of accident and sickness occur. Many workmen continue to work even when really incapacitated, and only when the slack season comes do they take advantage of the opportunity to consult a physician. This, it is asserted, accounts for the increase of sickness during such periods."

Another doctor writes thus:

"The psychic factor is also important. . . . With the progressive division of labour, work

has become more and more mechanical. . . . A definite share of over-fatigue and its sequels, especially neurasthenia, must be ascribed to this monotony ; to the absence of spontaneity, or joy in work. . . .

Of greater importance is the excessive overstrain of piece-work, which indeed pays better, but at the cost of a speed and intensity of work which was formerly unknown. That these injurious effects first assail the weaker part of the working population is self-evident. My own observations, especially in textile mills, confirmed the frequency of anæmia, and neurasthenia, especially among young women."

Finally, the situation is summed up as follows by a well-known Italian, Dr. Treves of Turin :

"Does what physicians call 'exhaustion' really exist in the working population ? This question, which was not thought of in the earliest studies of neurasthenia, since neurasthenic conditions were supposed to be ailments of the liberal professions and those engaged in intense intellectual application exclusively, has to-day been answered by the medical profession in the affirmative ; the daily observation of workers in hospital and dispensary has led to this conclusion. . . . Overstrain resulting from occupation does exist ; it is also entirely possible to combat it ; there is, in short, a problem of overwork. . . .

This overstrain, which physiologists, psychologists, clinicians, and above all nerve specialists and alienists, encounter so often as to be no longer deceived by it, does not present a well-defined morbid picture ; but it is a slow deviation often obscured by its very slowness, and predisposing to illness of any nature ; it is the borderland of illness."

Now, it seems to me that the conclusion to be drawn from such statistics and medical evidence as I have quoted, is that the German working day was too long. No doubt there were subsidiary causes of the ill-health mentioned ; such, for instance, as constant anxiety about unemployment and the possibility of sickness, and so on. It seems true, nevertheless, that, the other conditions of work being what they were, the working day was too long.

If it could be shown that the working day is of such a length that the health of workers is detrimentally affected by it, most persons would assert at once that it should be shortened. This position would probably be taken up regardless of any economic consequences which might be involved in a shorter day. We have now come to treat lurid pictures of the awful consequences from the possible admission of this or that regulation into industry, with some suspicion. When the British Ten-hour Day Act was passed in 1847, a large body of persons in England regarded the measure as absolutely

destructive of industry. It was said that "ten hours paid only the expenses of the 'plant' and the wages of labour, and that if work stopped at ten hours, there would be no profit on the capital invested. . . . The surplus, then, whether it was one, one and a half or two hours beyond ten hours, was the only time from which a remunerative return for capital could be made, without which it could not be expected that men would carry on business.[129] Experience has taught us to examine statements of this kind without emotion. We know, of course, that the process of shortening the working day cannot proceed indefinitely, simply because there will always be *some* work to be done; but we know *also* that, if inventions make it possible to obtain a certain output from one-third of the energy expended upon it under an eight-hour day system, then the eight-hour day is no longer *necessary*,—even though demand for goods may increase, and other variable factors assume new values. So that, if it seems that the length of the present working day is incompatible with the health of industrial workers, we shall probably say at once that it must be reduced.

But not so unanimous an agreement will be obtained when the considerations are more ideal. Nevertheless, ideal considerations are weighty. Much of the world's work is an irksome necessity: surely, then, we should endeav-

[129] This statement was made by Joseph Hume in the British House of Commons.

our to get it done with as much expedition as possible, thus allowing more freedom for the exercise of men's higher capacities.

It is of some interest here to note a fundamental axiom of much scientific management thought. This is that *the industrial worker should expend in his occupation the greatest possible amount of energy compatible with constant good health.* A workman is not to be *over*-fatigued by his daily labour, for that would soon render him inefficient; but he is to work to the point at which over-fatigue does just not occur. I say this is an axiom of much scientific management thought; but, in truth, it is only axiomatic in that it is neither proved nor capable of proof, not in that it is self-evident. Further, it is not peculiar to scientific management thought: much popular thinking is based upon it. As illustration, consider the following statement: "An industry which uses up the vital energy of a worker in a few years is coining the nation's life-blood into dividends. No industry has a right to more than that amount of the worker's energy which can normally be replaced by the food and rest allowed him." [130] *That is to say*, in the opinion of the writer of this statement, an industry *has* the "right" to the *whole* of the worker's energy "which can normally be replaced by the food and rest

[130] Quoted by Professor R. F. Irvine in an article entitled "Trade Unionism and Efficiency" (*Trade Unionism in Australia*, edited by M. Atkinson, 1916, p. 33).

allowed him "! Almost the only criterion popularly used to determine when a man has worked enough is the principle that "undue" fatigue is not justifiable. This, no doubt, represents a step forward; but cannot we take another? I wish to emphasise, in the light of the discoveries described in this course of lectures, that a further step forward is easily *possible.* From the point of view of the State, there is no difficulty, providing application of science to industry be allowed, in holding the principle that no man must expend, in his daily occupation, so much energy that he has none left, at the end of a normal day's work, for the exercise of his mind and imagination.

It is worthy of note that Taylor's curious statement that scientific management represents the essence of industrial democracy seems to be explained by his unconscious acceptance of the above-stated "axiom." If this "axiom" is assumed by *everyone*, then everyone accepts at the same time, by implication, the laws for the best use of the energy expended, that is, the laws which are applied by the scientific management expert. Taylor supposes, as it were, that the "axiom" represents the general policy of a whole country, and that the scientific expert's task is purely administrative. The expert is the cabinet of a single party parliament. If, however, the "axiom" be not accepted by everyone, there is no presumption that everyone will accept the scientific management's adminstration.

And there is no reason why anyone *must* accept the "axiom," as it is simply an *obiter dictum* as to what *ought* to be.

(*c*) There are, then, two points in the foregoing considerations which I wish to make prominent. The *first* is that the application of scientific management might be democratised with good results. As a consequence of such a democratisation, "tasks," for instance, would probably be set reasonably, and this alone would do away with much cause for annoyance with the system; and, again, labour would co-operate more willingly, as it would not feel that the new movement was destroying its safeguards. *Secondly*, labour might be offered some very considerable inducement to adopt the new methods. If this took the form of a shorter working day, for example, labour would feel that some permanent good was being offered, and would probably set itself in earnest to the work of making the new system a success. In this way, also, would industrial fatigue be lessened, and the danger of social fatigue, in the presence of which no great human work seems possible, would be warded off; while better conditions would exist for an ideal life.

§ 6

Conclusion

Let us now bring together the chief points discussed in this lecture.

We have been concerned with the question whether the application of psychology to industry is desirable.[131] In considering this question, it was found advisable to discuss scientific management similarly, since it is only in connection with scientific management that psychology has been, or is likely to be, applied to industry. From a cursory examination, it seemed that the only persons who might find the application of psychology to industry *un*desirable were industrial workers. The answer to our main question thus required an analysis of the whole situation from labour's point of view.

In the course of this analysis, we discovered that, without exception, all labour's important objections to industrial psychology were really directed against the method by which it had been put into practice. Certain of labour's objections, it is true, seemed to rest upon confused thinking; but there were two,—the autocratic tendency of scientific management, and its relation to collective bargaining,—which

[131] This question scarcely arises, of course, where the applied psychology obviously effects a saving of life; for instance, in the selection of men for railway engine-drivers, etc.

seemed based upon undoubted fact. It seemed, also, that labour's hostility, so far as it was based upon these two objections, was not unreasonable. If the matter had ended there, we should have been forced to the conclusion that, for labour, at least, the application of psychology to industry is *un*desirable.

This, indeed, is where the matter rests at the present moment. Looking ahead, however, we see that certain modifications in the method by which the application of psychology to industry is made, are possible. These modifications consist in a further democratisation of workshops, and in offering to labour, perhaps in the form of a shorter working day, a larger share of the new profits than has hitherto been given it.

If these modifications were introduced, the application of psychology to industry would probably seem to labour highly desirable, and the worker would be as eager as anyone to adopt the new discoveries. For the aim of labour is to increase its share of common human goods. Such an increase, of course, is not secured by simply increasing the productivity of the human energy expended in industry; but while this is obvious, it is equally obvious that the greater the profits the greater the *possible* share of them for labour. Intelligent workingmen must realise, I think, that, in the words of Professor R. F. Irvine, "it is impossible to keep on raising incomes indefinitely without

increasing production." [132] If, then, labour's protective rules and institutions were safeguarded and if an unambiguous and considerable share of the new profits were accorded it, there seems no doubt that it would find the application of psychology to industry very desirable. Assuming these conditions, the answer to the question with which we have been concerned in this lecture is in the affirmative. If the application of psychology to industry is desirable to labour, it is desirable to all.[133]

I shall conclude by emphasising the great fact about which these lectures have centred. This is that, by certain applications of psychology to industry, it has been found possible to obtain a given output from a much smaller expenditure of human energy than that hitherto necessary. This, I think, is a great fact: it is for men to say how they will use it. Psychology has now to turn to its laboratories again. *Its* task is to better what has been done. To devise practical methods by which its results, and those of other sciences, may be available for the enjoyment of all, is the task of society in general, and especially of labour and capital.

[132] *Trade Unionism in Australia* (p. 35); see note No. 93.

[133] *Cf.* F. W. Taylor (*The Principles of Scientific Management*, pp. 135-139).

THE END

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